Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

270 VOLT DIRECT CURRENT

GENERATING SYSTEM

DESIGN, DEVELOPMENT AND TEST

FINAL REPORT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

LUCAS AEROSPACE
POWER EQUIPMENT CORPORATION
777 LENA DRIVE
AURORA, OHIO 44202

AUGUST, 1991

Prepared For
Naval Air Systems Command
Department of the Navy
Washington, D.C. 20361-0001

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Final Report

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CONTENTS

1.0 INTRODUCTION

This report details the design and pre-flight testing of a 45 kw, 270 volts d.c., 9000-18000 rpm, brushless, conduction oil-cooled generator and associated system control and protection unit (GCU).

The effort was undertaken under contract to the U.S. Navy, Air Vehicle and Crew Systems Technology Department. The design and performance objectives were in accordance with U.S. Navy specification NADC-60-TS-7803 dated 5 January, 1978.

The primary objective of the development was to demonstrate the practicability of producing a wide speed range generator operating in a 270 volt d-c system capable of meeting transient and ripple voltage requirements.

2.0 SYSTEM DESCRIPTION

The 45 kw, 270 volts d.c. Generating system consists of:

Description	Model No.	Unit Weight, Pounds
45 kw, 270 volts d.c., brushless, conduction oil-cooled generator (with integrated oil supply; pump, filter, etc.)	30527-000	72.00
Generator Control Unit	51527-000	5.75
Current Sensor	50527-000	1.70

The system is designed to the requirements of NADC specification NADC-60-TS-7803. The system is designed for normal operation in the following configurations and for change from any one of these configurations to the other in flight or on the ground:

a) Parallel operation of two, three, or four generators. (Only the two generator parallel system was demonstrated as part of this program.)

b) Operation of the generators and their associated load busses as isolated systems.

c) Any combination of parallel and isolated channels compatible with the bus and generator arrangement.

The system control diagram is shown on drawing 51527-250. This drawing provides a logic function diagram for the generator control unit illustrating the operation of all control and protective functions as well as the SOSTEL interface.

The generator is a two bearing, oil-lubricated, conduction oil-cooled machine with two, three-phase stator windings, phase shifted 30° and full-wave rectified with two bridges connected in parallel through an interphase transformer. A three phase permanent magnet generator provides power for excitation and control functions. The generator includes an inter-neutral transformer that is used for diode failure detection, feeder fault detection, paralleling control, and current limiting. Also included are two overtemperature switches which provide stator overtemperature warning followed by activation of an automatic mechanical disconnect at a higher temperature.

The generator control unit is a convection self-cooled unit that contains the voltage regulator, control and protection circuits for coordinated system performance under both normal and abnormal system conditions, and the generator system interface to accommodate status interrogation by the SOSTEL power management system. Control power for operation of system power contactors is also provided from the GCU.

The voltage regulator, a pulse width modulated type, provides control of the generator exciter field current to maintain constant voltage at the point of regulation. Paralleling control provides equal load sharing between two or more generators operating in parallel. Current limiting is also provided to limit the overload current to 150 percent of rated load.

Protective functions provided for the system include overvoltage, undervoltage, overexcitation, underexcitation, feeder fault, faulted (open or shorted) generator output rectifier, excessive ripple and differential voltage. In addition to the voltage regulator, paralleling, current limiting, and system control power, control functions include a generator control relay and line contactor control.

The GCU provides eight SOSTEL channels for each generator system. Two channels provide system and generator thermal status information for power management and maintenance storage. The remaining six channels, one for each protective function, provides maintenance information as to which protective function actuated to trip the generator channel due to abnormal conditions.

The current sensor is designed to be installed on the positive generator output feeder and provides a d-c output voltage that is proportional to the magnitude of the current in the feeder. A similar device is installed in the negative return in the generator and the two current signals are used to detect feeder faults by sensing the differential between sensors. The generator sensor also provides the signal for current limiting and for load sharing during parallel operation.

The equipment is designed to have a useful life of not less than 15 years under any combination of operating and storage conditions. The generator has a calculated thermal life which indicates it will exceed 10,000 hours while the generator control unit and current sensor exceed the required 20,000 hours.

The system is designed to provide its rated output at the point-of-regulation (POR) over the generator input speed range of 9,000 to 18,000 RPM. The system is also capable of delivering 125 percent rated current for a minimum of two minutes and 150 percent rated fault current for a minimum of 7 seconds. The generator is sized to include a 10 volt feeder drop between the generator and the POR at rated system load.

The generator voltage regulator will regulate the steady state voltage to the limits shown when operated over the rated speed range of 9,000 to 18,000 RPM:

	Load	Regulation
a.	Loads between minimum and rated load	270 ± 5 volts
b.	Loads between rated and 125 percent of rated load	270 ± 10 volts

The output voltage will also remain within the limits shown when the generator is driven at 19,800 RPM overspeed with minimum electrical load applied.

Because of the nature of a rectified a-c generator, a minimum load must be defined when specifying performance parameters such as regulation, transient recovery and ripple. At generator loads below this minimum value, voltage modulation occurs because of an inability of the generator output filter capacitor to discharge faster than it can be recharged. The voltage modulation causes no damage or degradation to the generator or regulator and is not seen on the load bus, but it does make the measurement of output voltage meaningless. The minimum load defined for this generator system is 5.0 amperes, which is provided by a bleeder resistor external to the generator.

To ensure that the system will be electromagnetically compatible, the following precautions have been taken in the design of the generator, generator control unit and system interwiring with a view to minimizing electromagnetic interference:

a) Circuit designs provide for minimum noise generation and susceptibility.

b) Interference-free components were used.

c) Circuits and components that may have adversely affected one another, were isolated and separated.

d) Components within a circuit function were grouped together to minimize wire lengths between components.

e) Ground returns were carefully routed within circuits and between circuits to minimize stray coupling and ground loops.

f) Enclosures were designed to ensure proper mating of interface surfaces and radiation shielding.

g) Shielded ground pins are provided in the connector for grounding aircraft wire shields to chassis ground.

The conduction oil-cooled generator has no enclosure openings and provides low impedance bonding to the drive gearbox. Filter capacitors are connected across the parallel bridge output.

The switching voltage regulator and switching-type regulated power supplies are the principal sources of electromagnetic interference in the GCU. Control of switching speeds is used to minimize noise generated by these sources. Shielding of the PMG and exciter field wires will be required to minimize radiated emissions as a result of voltage regulator switching. A separate connector pin is provided for each aircraft wire shield to ground the shield to the equipment chassis inside the unit. All externally exposed metal parts are grounded to their respective chassis by providing good conductivity across the mounting surface.

The CMOS integrated circuit devices that are used extensively in the GCU have an inherent high noise immunity and susceptibility is not considered to be a problem area.

An important element in the reduction of radiated interference (emission and susceptibility) is the design of the equipment enclosure. An ideal shield would have extremely high conductivity, great thickness, high permeability, and is virtually watertight with no openings or discontinuities. A practical shield represents compromises dictated by weight and space limitations. Therefore, the GCU enclosure is a deep drawn aluminum structure with a single overlapping cover resulting in a minimum number of openings.

Proper grounding is another significant factor in providing noise immunity. Each circuit board is carefully designed with separate ground returns as required to ensure that ground loops within circuits are avoided.

System integral control power is derived from the permanent magnet generator (PMG) located in the generator. The PMG is a three phase ungrounded power source which is electrically independent from all other power sources. This supply is rectified within the GCU and at that point the GCU establishes the ground reference for the system integral control power. For grounding purposes, a control power return, separate from the main system ground, is made available through a pin of the operational connector on the GCU.

Drawing 51527-250 describes the system logic and control of the system. The system is designed for single or parallel operation. A single pole three position switch provides for cockpit control. With the switch in the "ON" position, build up and connection to the load bus and fault protection are automatic. No source of power other than that provided by tne generator PMG is required.

As the engine is started, PMG power increases proportionately. At a speed of approximately 5,500 RPM, sufficient voltage is available from the PMG for all control and protection circuits to become active; however, the generator control relay (GCR) will not close until the underspeed circuit picks up at approximately 8,000 RPM. When the GCR closes, the generator will be energized. As the underspeed circuit picks up and the GCR is closed, the inhibit on the undervoltage time delay is removed and the start-up control switch from the underspeed circuit to the GCR control is locked out.

As the generator voltage builds up, the undervoltage circuit will pick up. The line contactor control circuit will provide a "close" signal to the line contactor when the generator voltage is within 5 volts of the bus voltage. If the bus tie contactor is closed, the equalizer relay in the GCU will be energized as the line contactor closes and connect the parallel control circuit to the equalizer bus. The system is now operating normally supplying power to the load bus or busses operating as a single generator or in parallel with other operating generators. All protective circuits are active and SOSTEL interrogation will provide a normal indication.

Shutdown of the system can be accomplished by placing the generator control switch to the "Off-Reset" position. This acts to deenergize the generator by opening the generator control relay (GCR), which in turn will open the line contactor to disconnect the system from the load bus. SOSTEL interrogation will indicate normal since no fault signals are present.

The other form of normal shutdown occurs on engine shutdown with the generator control switch "ON". For this condition, an underspeed signal at approximately 8,000 RPM will result in a GCR trip signal after a 2 to 3 second delay. However, the GCR latch circuit is not triggered. As the GCR opens to deenergize the generator, the line contactor is also opened to disconnect the system from the load bus.

This operation deviates from the specification requirements and the following is the rationale for using it:

1) To prevent a single wire failure from resulting in a sustained generator full-field condition, undervoltage protection is used to deenergize the generator in addition to disconnecting it from the load bus. An open voltage sensing wire will result in a system overvoltage, but appear as an undervoltage to the GCU.

2) Using the undervoltage to trip the GCR, underspeed inhibits this function during normal start-up or shutdown to prevent a nuisance "lock-out", which would require a manual cycling of the generator control switch to reset the system. This inhibit also prevents false fault indications. In addition, there is no advantage to having the generator energized at speeds below the minimum speed for regulation. A 2 to 3 second time delay was selected to prevent nuisance tripping due to normal underspeed transients.

During normal operation if any of the following faults occur, the generator will be deenergized (latched) and disconnected from the bus and a "trip" signal indicated to SOSTEL:

Feeder fault.

Shorted main rectifier (0.3 - 0.5 second delay).

Undervoltage/Underexcitation (5 - 7 second delay).

Overvoltage/Overexcitation (inverse time delay).

Overcurrent (7 - 10 second delay).

The following faults will trip (latch) the line contactor and provide a field indication for SOSTEL:

Open main rectifier (5 - 7 second delay).

Excessive ripple (5 - 7 second delay).

The following paragraphs describe briefly each protective function. The generator control unit design and function are described in detail later in this report.

Feeder Fault

Current sensors located on the positive feeder and in the generator negative return provide voltage signals proportional to the magnitude of the current. If the negative signal exceeds the positive signal by more than 35% of the rated generator current, a trip signal is applied to a bi-stable flip-flop, which in turn trips the GCR and disconnects the generator from the load bus.

Shorted Rectifier

A shorted main rectifier is detected by a combination of signals. An inter-neutral transformer senses the ripple voltage existing between the displaced stator windings and also a large increase in amplitude that is accompanied by an increase in the field current ripple. This results in a trip signal after a 0.3 - 0.5 second time delay which deenergizes the generator and disconnects it from the load bus.

Undervoltage/Underexcitation

An undervoltage condition (or underexcitation) during parallel operation that is not accompanied by an underspeed signal trips the bi-stable latch circuit after a 5 - 7 second delay and thus trips the GCR to deenergize the generator and disconnect it from the load bus.

Overvoltage/Overexcitation

An overvoltage (or overexcitation) condition during parallel operation triggers an inverse time delay which in turn triggers the bi-stable latch circuit to trip the GCR and line contactor.

Overcurrent

The current limit circuit acts on the regulator to limit generator output current to 150% of rating. As this threshold is exceeded, the circuit triggers a 7 - 10 second time delay which in turn acts to trip and latch the GCR and trip the line contactor.

Open Rectifier and Excessive Ripple

The inter-neutral signal from the generator and a normal field current ripple signal indicate an open main rectifier for either single generator or parallel operation. Excessive ripple (greater than 12 volts peak-to-peak) of the generator output voltage may be indicative of a failed output filter. These functions trigger a 5 - 7 second time delay circuit which in turn triggers a bi-stable latch circuit that trips the line contactor, but does not deenergize the generator. A "fault" indication is provided for SOSTEL. The generator is maintained in a stand-by status and will be automatically connected to the load bus if the remaining generator systems are lost or shutdown.

False Trip

All protective circuitry is designed to prevent the possibility of tripping for faults other than those for which the protection is intended. Tripping will not occur during normal system operation, i.e. during system buildup, load switching transients, normal input speed changes, etc. The design also considers the possible effects of susceptibility to conducted and radiated electromagnetic interference (EMI) as well as switching relay transients.

3.0 GENERATOR DESCRIPTION

3.1 Electrical Design

The electrical part of the generator consists of three major components: the main generator, the exciter, and the permanent magnet generator (PMG). In addition, vital segments of the electrical design are the output rectifier bridge, interphase transformer and filter capacitors.

The main generator stator and rotor consist of laminated structures assembled from cobalt-iron alloy laminations.

The stator core is wound with an asymmetrical, 6-phase wye-connected winding. In effect, this winding is two, separated, 3-phase windings displaced from one another by 30 electrical degrees. Each of the two windings is connected to a full-wave rectifier bridge. The two output bridges are connected in parallel separated by an interphase transformer. The transformer absorbs at any instant the voltage difference between the two bridges and thereby ensures 120 degree conduction and balanced load sharing by each of the 12 output rectifiers. This winding - rectifier arrangement yields a 12 pulse system of rectification (ripple frequency is 12 times fundamental, i.e. rotational frequency) and minimum voltage ripple. Construction details and component ratings of the output bridges are discussed further in the Mechanical Design section of this report.

A non-salient pole, six-pole, distributed field winding configuration was chosen in preference to a salient-pole with concentrated field coils. This was done for structural integrity because support of the windings and the lamination geometry itself minimize concentrated areas of high stresses. In addition, cooling of the windings is improved because resistance losses are more uniformly distributed around the rotor periphery.

The main field winding is of rectangular magnet wire and held securely in slots. The winding is distributed around the rotor periphery. The number of slots is chosen to yield a sinusoidal distribution of air gap flux density.

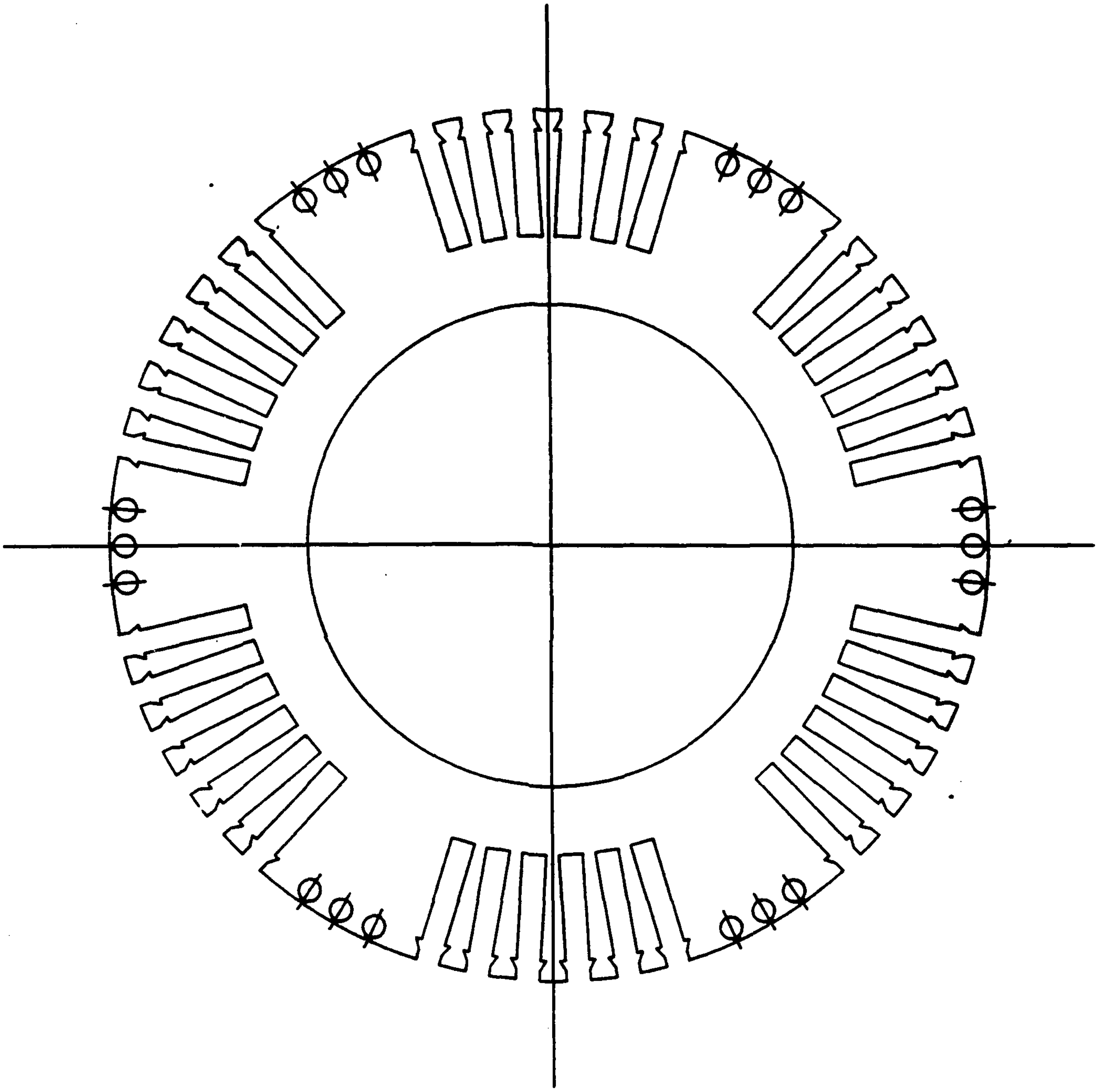
In the usual aircraft type of a-c generator, the salient pole configuration is used. A "squirrel-cage" damper winding is contained in slots in the pole-head. This winding ensures stability with parallel operation and minimizes the effects of the negative sequence field produced with load unbalance. In the non-salient pole, distributed field winding type of generator, the conductive rotor slot wedges are used as the damper winding and usually no damper winding, per se, is used.

The LAPEC model 30527-000 generator employs beryllium-copper alloy rotor slot wedges. Initially, this approach was deemed adequate for an appropriate damper winding circuit. During the course of development testing it was found that with a relatively high value of capacitance shunting the load, the output voltage would modulate severely. This instability would appear and disappear depending on generator speed and the magnitude of output load current. To solve this stability problem, the main generator rotor design was changed to include a squirrel-cage damper winding (similar to that in salient pole machines). Slots are punched in the pole-centers and round copper bars placed in these slots. These bars are connected on each end by brazing to copper end laminations. A representation of the rotor lamination geometry is shown on Figure 3-1. The additional damper circuit totally eliminated all tendencies toward instability.

Excitation power for the main generator field is supplied from a three-phase exciter whose output is rectified to d.c. by a three-phase, full-wave bridge. The design of the exciter generator is coordinated with the excitation requirements of the main generator and voltage regulator control. Silicon steel laminations are used in the stationary field and rotating AC armature of the exciter, since the weight-size saving of cobalt-iron alloy does not justify the resulting cost increase in the exciter configuration.

FIGURE 3-1

ROTOR LAMINATION



The permanent magnet generator (PMG) is designed to provide integral control power suitable to meet all the system requirements. This includes power for generator excitation through the voltage regulator, control power needs and external system requirements. The PMG is both air and short circuit stabilized for consistent and stable operation. In order to keep the length of the rotor (and the generator) to a minimum, as well as provide a ring-band-supported casting for the Alnico VI magnet structure, the PMG is designed as an "inside out" design with the rotating magnet on the outside of, and surrounding, the stationary wound stator.

The output of the PMG is tapped off to a full-wave rectifier bridge arrangement to supply power to the generator-mounted disconnect solenoid. When the generator's main stator end turn overtemperature switch is closed by an overtemperature condition, the power from this bridge energizes the disconnect solenoid, thus activating the mechanical disconnect mechanism, and appropriately conditions the SOSTEL resistance interface. The electrical schematic diagram on the generator outline drawing 305270000 shows the circuitry.

TABLE 3-1

LAPEC GENERATOR
MODEL 30527-000
ELECTRICAL PERFORMANCE CHARACTERISTICS

Rating (continuous)	45 kw
Overload (2 min.)	56.25 kw
Overload (7 sec.)	67.5 kw

RATED VOLTAGE

P.O.R.	270 volts d.c
Gen. Term.	280 volts d.c.

SPEED

Normal	16,000 rpm
Range	9,000 to 18,000 rpm
Overspeed	19,800 rpm
Proofspeed (Qualification)	21,600 rpm

EFFICIENCY

(Calculated)	87.6%

3.2 Mechanical Design

The generator consists of two sections, the oil supply adapter section and the generator section. The oil supply adapter shall hereafter be referred to as the adapter.

3.2.1 Adapter

The adapter has the generator proper mounted to it. In turn, it mounts the resulting adapter-generator assembly to the engine drive gearbox. It houses the generator integral cooling oil supply components which are described in greater detail in the following paragraphs. The adapter and its mounting relationship to the generator proper is shown on the outline drawing (305270000/0001 in the appendix. A "cutaway" drawing showing the generator/adapter's internal construction can also be found in the appendix.

The adapter housing is an A357-T7 aluminum sand casting with suitable ports, oil passages, etc. to accommodate and provide for the cooling oil supply requirements. The configuration may be best understood by viewing the generator outline drawing found in the appendix.

The mechanical disconnect is composed of a worm gear and a plunger driven worm sector. The worm gear is splined to the adapter main shaft and is axially engaged, through mating jaw teeth, to the adapter input drive shaft. The plunger-mounted worm sector is retracted and cocked in the normal operating mode and held in this position by an electrical solenoid-actuated locking pin. Should an extreme overheat condition occur within the generator, a stator end-turn mounted thermal switch will close and the solenoid will be energized thus retracting the plunger locking pin. The spring-loaded plunger will then be released and will drive its worm sector into engagement with the rotating worm gear, thus axially retracting the worm gear. This in turn, will immediately separate the driving axial jaw teeth previously described and stop the adapter main shaft rotation and consequently that of the generator rotor. The input shaft will continue to rotate and will be retained in the drive gearbox spline. The disconnect splines are normally running in the oil within the adapter housing which serves as the oil system oil sump. Therefore, the disconnect mechanism and the drive shaft are well lubricated in the normal mode, and in the disconnect mode as well if loss of oil is not the cause of overheat. Should a loss of oil, however, be the cause, residual oil and oil vaporat the input drive shaft's supporting ball bearing will provide sufficient lubrication until flight's end and corrective action is taken. Once the automatic disconnect is initiated, the SOSTEL interface is made aware of the condition. The stator's thermal switch condition is sensed by the GCU through the generator electrical connector and the proper SOSTEL interfacing is accomplished by the GCU. See the generator outline drawing in the Appendix for a review of the electrical schematic.

A reset of the mechanical disconnect mechanism can only be made on the ground by manually retracting the disconnect plunger handle and re-latching the solenoid's spring-loaded locking pin.

The adapter also houses the oil system main pump and main feed pump as shown on the generator outline drawing. The pump elements are positioned in tandem and are driven on a common internal shaft by means of a gear in engagement with a gear on the adapter main shaft.

The purpose of the main pump is to circulate the generator's self-contained oil through the aircraft-provided oil cooler and through the generator to cool it. the purpose of the main feed pump is to ensure a positive oil feed to the inlet of the main pump, particularly for sustained operation (at least 1 minute) in inverted flight. A schematic of the oil flow scheme may be seen on the generator outline drawing.

The input drive shaft conforms to the MS3334 accessory design standard and has a readily replaced drive spline sleeve. It is supported in the adapter by a ball bearing at one end and by the centering, disconnect drive jaw coupling at the other. The drive shaft incorporates a shear section designed to prevent disengagement of the O-ring packing from its drive gland in the event of a shear section failure. In the event of a shaft shear failure any oil leakage from the generator to the drive-adapter interface cavity drain should be minimal since the adapter pumps will cease to be driven.

Some of the adapter additional hydraulic components are listed below with a brief description. Their place in the cooling oil hydraulic circuit can best be seen by the hydraulic schematic shown on the generator outline drawing.

Starting from the discharge of the main pump, the components are:

a) The pressure regulator valve is of a sleeve valve arrangement. It is insensitive to any particle contamination. It bypasses the intended oil oversupply (for pressure regulation) of the main pump back to the oil sump at the maximum rated speed of the generator.

b) The case pressurizing aspirator uses the main pump bypass regulating flow to aspirate external air into the adapter case to prevent cavitation at the pump's oil inlet port.

c) A case pressure relief valve is provided to prevent excessive case pressures.

d) The vacuum relief and air filter valve gives entrance to aspirated air drawn into the case by the aspirator assembly and at cool down by contraction of the generator/adapter's contained air.

e) A 40 micron oil filter is provided to filter the main pump discharge oil flow to the external cooler. An integral bypass valve is provided for cold start-ups and to prevent unjustified "pressure drop" indications.

f) The oil filter assembly incorporates a "pressure drop" pop-out indicator to indicate a clogged oil filter condition.

g) An anti-drain valve is used as a simple check valve in the oil circuit from the cooler to prevent cooler oil drainage back into the adapter case.

h) A self-closing, magnetic drain plug of the bayonet (quick disconnect) type is used to check for magnetic particle contamination and to provide for drainage of the adapter oil sump. The plug is snapped out by a push and turn motion without the benefit of any tools and is not lockwired. The valve closes and the magnetic plug is exposed for visual inspection.

i) A quick-disconnect pressure fill coupling is used. It has a full-grip locking device to fully engage the pressure fill mating part. It is readily coupled or uncoupled without special tools.

j) A port for gravity oil fill is provided.

k) Inlet and outlet ports are provided for hydraulic line connections to the external oil cooler. Stainless steel inserts are used to provide solid, wear and thread-stripping resistance for these connections.

l) An oil level sight gage is provided in the location shown on the generator outline drawing.

3.2.2 Generator

The generator housing is made of an A357-T61 aluminum heat treated sand casting. It is mounted to the adapter by means of studs and self-locking nuts through a sturdy flange.

The generator's cooling oil passages are drilled to eliminate cooling passage coring in the casting. The housing walls are sized to withstand the hydraulic pressures of the cooling oil and the housing-to-stator shrink fit.

A containment calculation was made to assess the kinetic energy absorption capability of the generator main stator and housing. Calculating the kinetic energy of the rotor at the 21,600 rpm proofspeed condition as 1,761,060 in-lbs and the strain-energy absorption of the generator main stator and housing at 3,802,571 in-lbs, the containment requirement should be met even without taking an impact factor into account.

The generator housing also mounts the main output rectifier bridge, its output filtering capacitors, the output load sensor, the main terminal block, and the generator/gcu interfacing connector. Various aspects of the housing are covered in more detail in the following paragraphs.

The main stator consists of cobalt-iron alloy laminations axially welded across the outer periphery. Also welded axially across the outer periphery in four shallow slots are four straps extending beyond the end of the stack to enable the stator to be solidly bolted to the housing as well as being shrink-fitted to the generator housing oil passage sleeve.

Firmly attached and epoxy bonded to the stator winding end turns are two thermal switches. One is normally closed, which, when thermally opened, will indicate a precautionary, or "fault" overtemperature condition. The other normally open switch when thermally closed will energize the adapter's disconnect solenoid and cause an immediate disconnect of the generator from the drive.

The steel rotor shaft is of a large diameter, hollow, welded construction to provide a lightweight stiff structure. The main field core is shrink-fitted to the oil cooled main rotor shaft, for good heat transfer and drive over the generator's speed range. The exciter rotor assembly is piloted and bolted to the main rotor shaft for ease of assembly/disassembly. The PMG rotor is a close fit within the exciter rotor's cup-like support assembly to which it is keyed and axially retained by a beveled snap ring.

The rotor is supported by oil lubricated ball bearings at the ends of the rotor. The span between the rotor's bearings is relatively short. This, coupled with the large diameter of the rotor shaft, results in a rotor critical speed well above the generator's 21,600 rpm proofspeed.

The exciter stator laminations are riveted together, ground on the outside diameter and encased in a steel liner. The steel liner permits solid bolting of the exciter stator to the housing. It also prevents any buckling of the stack due to circumferential loads induced by the housing-to-stack differential contraction at low temperatures. The exciter stator (field) windings are machine wound on nylon bobbins encircling the exciter stator's poles

The exciter rotor is of conventional construction, except that its lamination's inside diameter was reduced to produce a section thicker than would be required for magnetic purposes. This was done to reduce the lamination bore stresses at the relatively high maximum operating speeds. Hoop-like bands are used over the rotor's winding end turns to constrain them over the generator's speed range.

The PMG stator is positioned within its rotor magnet bore rather than vice-versa in the conventional fashion. This "inside-out" configuration was configured in this manner to provide a compact, short generator because the entire PMG is packaged within the exciter section. The stator is firmly piloted and bolted to the generator housing. The PMG stator windings are connected to the generator electrical connector for transmission of power to the GCU. The windings are also tapped for rectification by a generator-mounted full-wave bridge circuit to provide self-contained power to energize the generator's disconnect solenoid. The circuitry is shown on the generator outline drawing.

The PMG rotor magnet is a cast Alnico, salient-pole type of an "inside-out" configuration. This means that it has poles protruding within its bore rather than from its outside diameter in the conventional manner. This arrangement permittted mounting the PMG section within the bore of the encompassing exciter rotor section resulting in a compact mounting arrangement.

The main field excitation diodes are housed within the rotor in the position most favorable position to withstand the 14,253g rotational "g" loads experienced at 18,000 rpm. Ceramic encased diode suppression resistors are used across the diodes for transient voltage spike suppression purposes. They too are well supported to resist the centrifugal "g" loads.

Electrical connections from the exciter rotor are made directly to the terminal ends of the diodes. They are directed radially inward through the exciter rotor support, supported by it, and the ends bolted to the diode terminal ends.

The diodes are electrically insulated from their mounting to the rotor shaft by means of thin, high temperature, polyimide insulation material. Cooling oil flowing through the rotor shaft cools the diodes by means of conduction to the oil.

Connections from the rotating diodes to the rotor main field are made through well-insulated plus and minus copper straps to the rotor-mounted diode output bridge. The diode output bridge connections are pre-wired prior to the insertion and mounting of the diodes within the exciter-rotor support.

The generator's oil-cooled bearings are of a full ball complement, HDB-105 size, and, have a bronze retainer configuration. They were qualified on the generator for the F-15 program and have given excellent service. Not one bearing failure has been experienced to date on the F-15 program or during the development of this 270 HVDC generator. Although the F-15 generator's rated speed is 12,000 rpm, this kind of bearing's "DN" value (the product of bore diameter in millimeters and rpm) exceeds 1.5 million. If this figure is used, then the limiting speed based on a 1.5×10^6 DN for this application is 60,000 rpm. This safely exceeds this generator's maximum operating speed of 18,000 rpm and also its 21,600 rpm proof speed by a significant margin.

Because the generator is conduction oil-cooled, three rotating oil seals are required; one at the adapter input shaft which must seal against the adapter's low case pressure, and one at each end of the rotor to seal against the cooling oil system pressure.

Spring-loaded, carbonface oil seals were ultimately used. Their stationary sealing rings are carbon rings with faces lapped to within two helium light bands. The rotating mating rings are also lapped to within two helium light bands. The stationary seal case is press-fitted in the housing and the mating ring is clamped and O-ring sealed to the rotor shaft. The static O-ring seals used are fluorocarbon, high temperature, compression set resistant, "O-rings" per MIL-R-83248.

The main output rectifier bridge is composed of three heat sink-diode assemblies. The largest of the three is the "negative" of the generator output, and it mounts six of the 12 output diodes. The other two smaller heat sinks make up the "positive" output portion of the bridge. They each mount three diodes comprising the remaining 6 diodes of the 12 diode array. The two positive heat sinks are connected to the interphase transformer as shown on the electrical schematic on the generator outline drawing.

Both the positive and negative heat sinks are made of an aluminum extrusion with an internal passage for oil cooling. The heat sinks are electrically insulated from the generator housing in accordance with the specification requirements. Positive and negative output leads are bolted to the heat sink and the terminal block mounting terminal studs with suitable lugs. Cooling oil is pumped through the heat sinks to conduction cool the main output diodes.

A capacitor array is connected across the output bridge for output power conditioning.

The output diodes are rated for a PIV of 1,200 volts and a current per cell of 72 amperes at a case temperature of 138°C. The average current required per diode for 1.0 PU, 1.25 PU, and 1.5 PU loads based on a 45 KW output are 27.8, 34.7 and 41.7, amps respectively.

A molded terminal block is provided on the end of the generator as shown on the generator outline drawing. Large stud-type terminals provide for surface to surface contact between the generator output conductors and the feeder leads. To "key" the output terminals in order to prevent misconnections, one stud (B+) is of a 1/2 inch diameter and the other (E-) is of a 3/8 inch diameter. A protective cover (not shown on the generator outline drawing) is provided.

A connector conforming to MIL-C-83723, Class H, Series 3 is provided on the generator to make the necessary connections to the GCU. Although only 12 pins are required, a M83723-79H1624N (#16 shell size) connector with 24 pins is used. This permits wider spacing of the pins to provide better pin-to-pin dielectric voltage resistance.

Conduction oil-cooling of the generator was chosen in order to avoid high windage and churning losses that could exist were spray oil-cooling to be used for a generator of this size at the 18,000 rpm max. operating speed, 19,800 rpm overspeed and 21,600 rpm proofspeed. The cooling oil management system is described by the cooling oil circuit shown on the generator outline drawing.

An oil flow is approximately 4.0 gpm (gallons per minute). The additional flow from the main circulating pump is by-passed to the sump at the 18,000 rpm operating speed by the adapter pressure regulating valve. This flow (approx. 3.5) gpm is adequate for an external oil cooler.

Stress analyses were made for the rotating components, that is, the main rotor, the exciter rotor, and the PMG rotor. The results of these stress analyses and the stress limits of the applicable components are listed in Table 3-2.

TABLE 3-2

BORE STRESSES - PSI

Speed	Main Rotor*	Exciter**	PMG***
9,000	8,686	7,593	3,735
16,000	27,453	23,997	11,804
18,000	34,745	30,371	14,939
19,800	42,041	36,749	18,076
21,600	50,033	43,735	21,513

*Stress yield point of cobalt-iron alloy is 55,000 PSI

** Stress yield point of lamination steel is 51,000 PSI

*** Tensile strength of Alnico is 23,000 PSI

Generator Weight and Overhung Moment

Model: 30527-000
Weight: 72.0 lbs. (dry)
Overhung Moment: 451.9 in-lbs (dry)

As noted above, the eventually developed generator came in over the specification weight of 52.0 lbs. and the LAPEC proposal weight of 58.0 lbs. The generator's overhung moment, however, was within the proposal's 456 in-lb. value and the specification's 550 in-lb. limit. There are a number of reasons for the generator's overweight condition. One was the result of a significant computer error in calculating the weight of the generator's main stator. Another was the post-proposal change in the generator's design. An evisioned weight reduced design turned out to be an overzealous one which could not be realized. Also, it is believed that the specification weight of 52 lbs. which could be considered realistic for a 45 KW rated generator alone at its nominal, 16,000 rpm speed, is not realistic for a 9,000 rpm minimum speed design with an integral oil supply adapter with its reservoir, pump, disconnect, filter, etc.

Materials and Processes Selections

Materials and processes used in the manufacture of the generator are listed on Table 3-3.

These materials and processes were selected to meet the environmental and corrosion resistance requirements during the life of the generator in accordance with the specification.

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Generator Housing	Aluminum Alloy	MIL-A-21180 Alloy A357-T61 Grade C, Class 2	None	Chem Film MIL-C-5541, 1 coat TT-P-1757 Primer plus 2 coats TT-E-489, FED-STD-595 enamel color wht. No. 17875	MIL-C-6021	LAPEC 16-023005 Method I
Generator Shaft Components	Alloy Steel Tubing	MIL-T-6736 (AISI 4130)	Nitride MIL-S-6090	---	MIL-I-6868	Inspect per LAPEC 99-500001
Shaft Spline Inserts	Alloy, Steel	AMS-6274 (SAE 8620)	Nitride MIL-S-6090	---	---	---
PMG Rotor	Permanent Magnet	Alnico 6	N/A	---	---	LAPEC 15-016208
Molded Coil Bobbin (Exciter)	Glass Reinforced Nylon 6/6	L-P-395 Type II Grade A	N/A	---	---	---
Arc welding (TIG) Generator Shaft	---		N/A	MIL-W-8611 Class B-1	---	LAPEC PS-1700

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Electrical Connection Brazing	Silver Brazing Alloy	Silver Alloy QQ-S-561	N/A	MIL-B-7883	---	---
Arc Welding TIG Laminated Stack	---	---	N/A	MIL-W-8611	---	---
PMG Stator Laminations	Silicon Steel	AISI Type M-22 LAPEC 15-016203	Magnetic Anneal LAPEC 16-011002	---	---	---
Main Stator Laminations	Iron-Cobalt Vanadium Alloy (Hiperco 50)	LAPEC 15-016209	Magnetic Anneal LAPEC 16-011011	---	---	---
Non-Structural Hardware	Carbon Steel Bar	QQ-S-634 Comp. 1018/1020	---	Treat per TT-C-490, Type I (For Varnish Adhesion)	---	Treat per LAPEC 16-023015
Exciter & PMG Rotor Support	Aluminum or Alloy 2024	---	Heat Treated	---	---	---

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Exciter Stator Stack Rivets	Carbon Steel	QQ-W-405 Comp. 1006/1010	None	---	---	---
End-Turn Support Exciter Rotor	Stainless Steel Tubing (304)	MIL-T-5695 1/4 Hard	None	---	---	---
End-Turn Support Band Main Rotor	Stainless Steel Tubing (Custom 455)	AMS 5617	Solution Heat Treated Precipitation Hardened at 1,050°F.	---	---	---
Bus Strip, Diode Assy.	6063-T6 Aluminum Alloy Extrusion	QQ-A-200/9 Condition T-6	Solution Heat Treated and Aged	Chem Film MIL-C-5541	---	---
Static Seal "O" Ring	Fluorocarbon Elastomer	MIL-R-83248 Type I, Class I	N/A	---	---	---
Generator Terminal Block	Dially Phthalate, Fiberglass Reinforced	MIL-M-14 Type GDI-30F	N/A	---	---	---

Impregnate	Diphenyl Oxide Resin	[illegible]	N/A	---	---	---
Fastener Anti-Corrosion Compound	Zinc Chromate Paste	TT-P-1757	N/A	---	---	LAPEC 05-651002
Anodizing Aluminum Alloys	---	---	N/A	QQ-A-8625, Type II	---	LAPEC 16-023013
Soldering Electrical Connections (Diodes)	Tin-Lead Solder	QQ-S-571 Type SB-5	N/A	MIL-STD-454 Requirement 5	---	LAPEC 16-018003
Chem Filming Aluminum Alloys	---	---	N/A	MIl-C-5541	---	LAPEC 16-023005 Method I
Passivation of Stainless Steels	---	---	N/A	QQ-P-35, Type II	---	LAPEC 16-023005 Method I
Magnet Wire	Polyimide Film Insulated Cooper Wire	MIL-W-583 Type M2	N/A	---	---	LAPEC 15-038273 Rectangular LAPEC 15-038272 Round
	Tubular Copper, Tinned					
Electrical Insulation, Sheet	Aromatic Polyamide	MIL-I-24204	N/A	---	---	LAPEC 15-014028
Electrical Insulation Filmtape	Polyimide Film (Kapton)	MIL-P-46112, Type I (W/Adhesive)	N/A	---	---	LSI 15-543204
Electrical Insulation, Sheet	Kapton/ Nomex/ Kapton Laminate	MIL-P-46112 and MIL-I-24204	N/A	---	---	LSI 15-014029
Electrical						

4.0 CONTROLS DESCRIPTION

4.1 Generator Control Unit

The 51527-000 generator control unit GCU is designed to the requirements of specification NADC-60-TS-7803/2 for controlling a 270 volt d-c generator in either a single or paralleled multi-generator system.

In addition to providing control for a generator in a single and up to a four generator paralleled system, the GCU provides the protection functions to ihsure that the channel is operating properly. In the event of a failure, the generator is deenergized, removed from the load bus and the channel trip status is presented to the SOSTEL power management system.

A detailed description of the operation of each of the circuit functions shown on logic diagram 51527-200 follows. The circuits discussed are in the order of control functions, protective functions and SOSTEL interface circuits.

Power Supplies

The unit accepts high voltage three phase power from the permanent magnet generator and converts it for use in powering the main generator exciter field, a regulated high voltage auxiliary power supply, and the low voltage control circuits within the GCU. The main generator exciter field supply is regulated at 270 volts. The high voltage is used in order to minimize the number of stages of power conversion and the supply is regulated so that stable generator control can be maintained under conditions of high speed and light generator loads. High voltage NPN transistors connected as a Darlington pair form the heart of the switching regulator which is powered by the PMG rectifier bridge. In order to avoid the need of a high voltage PNP driver transistor for the Darlington pair, a separate floating driver supply is formed from an auxiliary winding of the step down transformer used for 28 volt control power. This lower voltage rated PNP transistor which, in turn, is driven from the 28 volt control logic.

The 270 volt, 0.5 ampere auxiliary supply is powered from the same switching regulator used to provide the 270 volt exciter field power supply. In order to maintain a good quality of power on the auxiliary supply, it is diode isolated and separately filtered. The voltage transients due to field current switching are thus prevented from appearing on the auxiliary supply. A diode isolated 270 volt output for bus tie contactor control is powered from this auxiliary supply.

The 28 volt DC control power for the GCU is provided by a step down transformer and a low voltage switching regulator. The switching regulator is used because of the large range of PMG voltage which is produced over the 2:1 generator speed range. In addition to the use of the 28 volt power supply by the internal GCU control circuits, the voltage is supplied to the generator control switch, the line contactor and bus tie contactor auxiliary contacts, and the current sensing current transformers. In the event of an overload (greater than one ampere) or a short circuit on this supply, current limiting is employed to protect GCU internal components. An additional 15 volt supply is provided for the single sided operation of comparators, operational amplifiers, and logic circuits.

Voltage Regulator

The voltage regulator circuitry is essentially the same design as that which LAPEC supplies to Boeing on the ALCM program, a 28 volt rectified system. Two operational amplifier stages within the regulator provide for the proper input voltage compensating network and exciter field current feedback, both of which are essential for stabilizing the control loop and providing optimized response, especially when controlling a generator over a large speed range. The best choice of a compensation network and value of exciter field current feedback was determined by computer modeling of the control loop as well as laboratory testing. The various generator constants for this linearized model are determined from the generator design curves at no load and high speed, the most critical condition for stability. Since it is desirable that a single regulator circuit be used to control machines with different ratings, and therefore, different characteristic parameters, this modeling was useful in predicting the effect that the varying parameters have on the system response.

The rest of the regulator consists of a high pass filter, for the ripple, which produces pulse width modulation at the output of the summing and voltage comparison amplifier. This pulse width modulation signal is used to drive the current amplifier which controls the current flowing in the generator exciter field. A free wheeling diode is provided across the field of the machine to maintain constant current flow when the transistors switch off. A high voltage NPN transistor (Darlington) is used in switching the field current. The PNP driver transistor in this configuration is tied to the 28 volt supply, thereby eliminating the need for a high voltage device. A low value sensing resistor on the emitter of the field driver transistor is used to feed back a signal proportional to the magnitude of field current to the voltage regulator, thereby stabilizing the control loop.

This type of control circuitry is characterized by smooth and stable transitions from "full on" or 100 percent duty cycle down to less than 5 percent duty cycle. These conditions may be found from minimum load to full load over the wide speed range of the machine. As mentioned previously, the field power supply itself is regulated, this being done to put a limit on the voltage available to the field at high generator speeds. Unstable operation would otherwise occur because the high PMG voltage would result in a high regulator gain, at the same time that the high speed results in a high gain in the exciter.

Another consideration for stable operation at light load is voltage modulation caused by the inability of the generator filter capacitor to discharge, a problem not encountered in a conventional brush-type machine. Based upon a ratio from past experience, the minimum load should be approximately 5.0 amperes. This minimum load is a permanently connected load.

The range of adjustment of the regulated voltage is from 255 volts to 290 volts. This adjustment is made by removing the top cover and turning the potentiometer with a flat blade screw driver. The potentiometer changes the regulated voltage by varying the reference which is presented to the voltage regulator.

Paralleling Control

The signal from the current sensor in the generator neutral leg is used by the paralleling control to cause the load to be shared equally by all of the generators tied to the load bus. The paralleling control senses the voltage difference between the equalizer bus and the current sensor signal to determine load sharing. If the equalizer bus voltage is greater than the local generator load current signal, this indicates that other generators are carrying more of the load than the local generator, then the paralleling control biases the voltage regulator circuit to supply more excitation to the local generator. A large time constant is used with this circuit to avoid unstable operation or load swapping.

The equalizer relay, KEQ, is used to prevent one GCU from trying to share load with a second GCU which is not on line. The KEQ relay is energized, connecting the GCU to the equalizer bus only when the line contactor and the bus tie contactors are closed.

Current Limiting

The current limiting circuit serves to limit the generator output current by lowering the regulated output voltage during periods of heavy load. At 1.5 times rated generator load, the voltage from the current sensing transformer within the generator exceeds a threshold value and the current limit circuit lowers the voltage regulator reference voltage. Since the current sensing transformer within the generator is sized to the generator rating, the same threshold voltage may be used within the GCU when controlling generators of various ratings.

A second threshold sensing circuit is used to start a timer, which after 7 to 10 seconds, results in a fault condition. Whenever current limiting has operated for this length of time, the reason is determined to be a bus fault condition that has not cleared, and the generator is deenergized and disconnected from the load bus in order to prevent generator damage.

Line Contactor Control

The line contactor control circuit provides 270 volt, 100 milliampere power from the regulated auxiliary supply to power the coil of the line contactor. Power is applied to the output pin by means of high voltage PNP Darlington transistors, rated for a collector voltage of greater than 400 volts. The transistors are driven by a high voltage NPN transistor which in turn is powered from the low voltage control logic gates. The operation of the logic circuitry has been described in the start up and shut down of the system description and not repeated here.

The differential voltage sensing is used to inhibit the closing of the line contactor until the POR voltage rises to within 5 volts of the bus voltage during build up. A differential comparator is used to provide this function. Since the difference voltage disappears once the line contactor is closed, this function is effective only during initial build up.

Field Relay Control

The field relay (GCR) provides for the safe and sure deenergization of the generator exciter field in the event that a failure condition has been recognized. An electromechanical, rather than a semi-conductor device was chosen for this function to insure that if an unexpected environmental condition exists which caused the failure of the field transistor, the same condition would not cause the failure of the device used for protection. The relay is a SPDT vacuum type, rated for 3 amperes at 2,500 volts, and 15 amperes at 300 volts. This gives adequate safety margin when considering that a maximum voltage supplied by the partially loaded PMG is 700 volts at high speed, and the field current at this voltage in a "full on" condition, is only 2.6 amperes.

Since the operation of the logic circuitry controlling the GCR was explained in the "system description", it is not repeated here. Note that the control ciricuitry does turn off the field circuit prior to the opening of the relay during normal operation, thereby eliminating unnecessary electrical contact wear.

Overvoltage/Overexcitation Protection

Overvoltage protection is used to prevent excessive voltage from appearing on the load bus in the event of a control failure. The POR voltage is sensed and compared to a reference which is independent of the voltage regulator reference. Once the sensed voltage exceeds 290 volts, the output of an integrator begins to ramp upward at a rate determined by the amount of overvoltage. When the voltage reaches a set level, the generator control relay is tripped, and the line contactor is opened. In this method, an inverse time curve of overvoltage is produced, which not only insures that allowable bus voltage versus time limits are not exceeded, but also prevents nuisance tripping due to unusual, but temporary, voltage transients. Because the POR sensing wire is used for both control and protection functions, an unsensed failure could result if this wire were opened. In this eventuality, the voltage regulator would falsely sense zero voltage and cause the field to turn full on, but at the same time OV protection would be lost. For this reason, the undervoltage sensing, which would sense this failure, is able to cause a generator control relay trip, deenergizing the generator and opening the line contactor.

During parallel generator operation, the overexcitation protection is used to selectively trip a failed channel, even though an overvoltage may not be present on the load bus. This is accomplished by using the output of the paralleling control to bias the overvoltage protection circuit to a lower threshold voltage. If the voltage regulator fails to respond to the paralleling control command to lower regulated voltage due to current hogging by the local generator, the condition is recognized as an overexcitation of the local generator, and a trip of the generator control relay results.

Undervoltage and Underexcitation Protection

Undervoltage (U.V.) protection is used to insure that a voltage less than 240 $\pm$ 5 volts is not maintained on the generator output for more than 5-7 seconds. The POR voltage is sensed and compared to a threshold voltage, and if the voltage is below the U.V. limit, and the generator control relay is closed and the system is up to normal operating speed, a timer is started. If the condition does not correct itself before the time is completed, the GCR is tripped and the line contactor is opened.

Underspeed

Underspeed sensing is used by the GCU to determine true failure conditions and, in addition, to automatically shut the channel off during engine coast down. One phase of the low voltage PMG waveform is squared and sensed by a pulse width discriminator circuit to determine the condition of generator speed. A PMG frequency below 800 Hz, which corresponds to a generator speed of 8,000 RPM, is defined as an underspeed condition.

Feeder Fault Protection

In order to sense a fault which occurs between the generator and the line contactor, two d-c current sensing transformers are used. The current sensors, which are described in Section 4.2, provide a d-c voltage proportional to the current flowing thru them. One sensor is provided close to the generator, in the generator neutral leg. A second sensor is mounted near the line contactor or the point of regulation. A current flowing through one of the sensors, but not the other is a fault current and this is detected as a voltage difference between the sensor outputs. A window comparator circuit is used to determine when the fault current reaches 63 +/- 5 amperes which is the feeder fault trip point. The fault condition causes the generator to be deenergized and the line contactor to be opened.

Failed Generator Rectifier Protection

The failed generator rectifier protection circuit is used to monitor the generator output rectifiers and to determine either an open or shorted rectifier condition. The open rectifier condition is considered to be a less serious failure, and if needed the generator still able to provide rated load continuously. Therefore, a generator with an open rectifier is placed on stand-by in the event that subsequent failures in other generators require the reinstatement of the first generator. The information of whether each generator is supplying current to the load is provided by auxiliary contacts on the line contactor and bus tie contactor. If both contacts are closed, the generator is "on line" and this information is provided to each of the other GCU's in a paralleled system. With the present design, when up to four generators are paralleled, each will receive the information on the status of the other three. More generators could be easily accommodated by this system should this be necessary.

The sensing of a shorted rectifier results in a trip of the generator control relay within 0.3 to 0.5 seconds. In this case, the generator is deenergized and the line contactor is opened.

Excessive Voltage Ripple Protection

An excessive voltage ripple circuit is used to determine the condition of the generator output voltage. If a failure, such as an open generator filter capacitor, should cause ripple in excess of 12 volts in either polarity on the generator output, the same action is taken as previously described for an open generator rectifier failure. The stand-by condition is again maintained unless the operation of the generator is required.

To accomplish this protection, the peak type filter circuit very similar to that described for the rectifier failure detection circuit, is used. The excessive ripple detection feature will work well with an isolated generator, but when operating paralleled generators, a failure such as an open filter capacitor is hidden by the action of the paralleled generator.

SOSTEL Interface

In order to report the condition of the various protection features of the generator control system, a series of resistances are switched into and out of the SOSTEL interrogation path. In each case except one, logic gates are used to drive optical isolators which perform the resistor switching. The optical isolators are used because the relationship of the SOSTEL interface ground and the GCU control logic ground is not known. The one exception to the optical isolator output is the generator thermal status. Under normal conditions, 720 $\pm$ 10% ohms are found across this output. If an overtemperature condition occurs within the generator, thermostat opens, raising the resistance across the output to 1100 $\pm$ 10% ohms. This is to be interpreted as a precautionary or fault condition. In the event that a mechanical disconnect occurs, a contact closure changes the resistance to 420 $\pm$ 10% ohms, the trip condition.

The system status is similarly reported to SOSTEL. In this case, a fault condition is presented only by the identification of an open generator rectifier or of excessive generator ripple voltage. This is the precautionary or stand by condition for the system. Each of the other failures produce a trip indication on this output. For the purpose of identifying which failure has caused a trip or a fault indication, the following protective functions are provided to the SOSTEL interface:

Open Rectifier	Overexcitation/Underexcitation
Shorted Rectifier	Overvoltage
Feeder Fault	Overcurrent
Undervoltage	Ripple Voltage

Either the normal (720 ohm) impedance or the trip (420 ohm) impedance is presented at each of these outputs.

Design and Construction

The outline of the generator control unit is shown on drawing 515270000. The package is designed to conform to the envelope dimensions and mounting requirements of specification NADC-60-TS-7803/2.

The electrical and physical design of the unit is made so that dependable performance is provided under any of the expected environmental conditions. The details of the design are discussed in the following paragraphs.

The generator control unit is constructed using a one piece formed aluminum base with the physically large and high heat dissipating components mounted directly to it. This chassis not only provides a secure mounting for components such as the circular connectors and the power transformer, but also provides a good thermal path for the power transistors and the transformer. Those components tied directly to high voltages are also mounted on the chassis wherever possible. The remaining electronic circuitry is contained on three horizontally mounted printed wiring boards above the chassis. The printed wiring boards are connected to the chassis components thru pin and socket type board connectors, which are mounted across the front face of the unit behind the circular connectors. These printed wiring boards are easily removed for servicing by removing the tie down screws at the rear of the unit. Circuit board guides along the length of the package provide additional support for the boards. This entire assembly is protected from the external environment by a deep drawn aluminum top cover and a flat aluminum bottom cover. Access to the voltage adjustment potentiometer is made from the back of the unit, after removing the top cover. Since in-service adjustment is not required, easy external access to it is not provided.

Electrical connections are made through each of the two circular connectors on the front of the unit, as shown on the outline drawing. All of the control system interconnections are made by means of the larger connector, numbered M83723-72R2255N, while the SOSTEL power management interface is made by the M83723-72R1212N connector. In providing a conservative design, a number of pins in the control connector are left vacant. Those pins adjacent to the three high voltage PMG input pins are not used in order to provide adequate pin-to-pin dielectric voltage isolation. This connector features 25% spare pins. The choice of SOSTEL system connector provides only one spare pin for future use.

The GCU is designed to operate in the maximum ambient temperature without depending upon heat conduction through the mounting feet. Heat is dissipated from the surface of the unit by natural convection and radiation. The design is also made to minimize the heat that is generated by using low power logic circuits and multiple transistor stages in high voltage switches.

Electrical Design

The generator control unit circuitry consists basically of digital MOS devices to perform the control and protection logic functions. High voltage switching is accomplished with NPN silicon junction transistors because these devices are readily available with voltage ratings greater than required for this design.

The design utilizes components which are readily available. Generous derating factors for component parameters are employed to insure reliable operation under sustained operation at the environmental extremes. The use of low power CMOS logic not only reduces the GCU internal temperature rise increasing the predicted reliability, but also provides for noise insensitive operation. Threshold levels for transistor switches are maintained at a high level to complement the noise rejection.

4.2 Current Sensor

The 50527-000 current sensor provides a d-c output voltage that is proportional to the current in the cable passing through the window opening of the sensor. The sensor uses a magnetic core with two magnetoresistors installed in the core air gap. The magnetoresistors (MR) are semiconductor devices that exhibit an increase in resistance as a function of an applied magnetic field. The MR devices are connected in a simple bridge circuit that will be unbalanced by the resistance change resulting from an increase in the flux density in the core as the cable current increases. The error signal from the bridge is amplified and drives a transistor connected as an emitter follower. This transistor provides a d-c current in a bucking winding on the core to re-establish bridge balance. The current in the winding will be directly proportional to the current in the cable (generator output) and thus produces an output voltage signal.

A stabilized permalloy alloy magnetic core is used to provide the magnetic field for the flux responsive magnetoresistor (MR) devices that are installed in the air gap. Two magnetoresistors have been used to compensate for the relatively high temperature coefficient of the devices, and the MRs are selected for matching resistance characteristics. The MRs are procured mounted on a thin silicon steel substrate and are epoxy bonded to the surface of the core in the air gap.

The core is potted into a metal can base assembly and small wiring board is installed above the core on stand offs and contains the remainder of the bridge circuit resistors, amplifier networks and driver transistor.

The sensor requires 28 volts input excitation voltage to provide 0 to 5 volts output voltage.

The 505270000 is designed for base-plate mounting with connector on the front provided for electrical connections. The feed through aperture provides a well radiused entry and exit to prevent cable chafing, and has a 0.75 inch diameter opening which will accommodate the required cabling.

Drawing 505270000 shows the general configurations and the outline dimensions of the current sensor.

The current sensor is a purchased item -- not a LAPEC product.

5.0 PREFLIGHT RATING TESTS AND RESULTS

In accordance with Navy specification NADC-60-TS-7803, preflight rating tests were performed on a single system and two parallel systems. A system comprises the model 30527-000 generator, Model 51527-000 generator control unit (GCU), and two Model 50527-000 current sensors.

In April, 1984, the contract was amended to delete the following specified tests:

Heat rejection and efficiency
Mounting position
Performance and endurance (50 hours)

In addition, "Dielectric Strength", was waived in November 1988.

These deletions and waivers were requested and granted with a view to expediting completion of the test program.

The following tests were performed:

	Test	Specification Reference	Page
5.1	Examination of Product	4.6.1	36
5.2	Overload	4.6.4	37
5.3	Voltage Regulation	4.6.7, 4.6.11, 4.6.12.4	38
5.4	Voltage Ripple	4.6.10	40
5.5	Short Circuit Capacity	4.6.9	38
5.6	Paralleling	4.6.12.1	41
5.7	Shutdown	4.6.12.2	43
5.8	Parallel Load Division	4.6.12.3	44
5.9	Overvoltage Function Trip	4.6.12.5	45
5.10	Undervoltage Function Trip	4.6.12.6	47
5.11	Protection Performance	4.6.14	50

Tests were performed under the following conditions:

Ambient temperature: 77 +/- 27 degrees Fahrenheit.

Ambient pressure: Sea level

Mounting: The generator was mounted with longitudinal axis horizontal;

generator control unit and current sensor assemblies were also mounted with their bases horizontal.

Voltage measurement: System voltage was measured at the point-of-regulation (POR).

Feeders: The feeders were sized to ensure a maximum voltage drop of 10 volts at rated current (167 amperes).

Generator Speed: Depending on the nature of a particular test, the generator was operated over its speed range of 9,000 to 18,000 rpm. Rated average speed is 16,000 rpm.

Excitation: The generator is self-excited and controlled by the GCU.

Warm-up: Prior to functional tests, the system (or systems) operated at rated conditions until components reached stabilized temperatures. Temperature stabilization is reached when the rate of change of temperature does not exceed four degrees Fahrenheit in one hour.

During the functional tests, the following measurements were made:

- Output voltage and current
- Excitation current
- Ambient temperature
- Generator windings and housing temperatures
- Inlet and exit oil temperatures
- Oil pressures and flow rate
- Generator speed

Thermocouples were installed on the generator to measure the winding, housing, and oil temperatures.

Instrumentation for the individual tests was chosen from the list shown on Table 5-1. All electrical meters and temperature indicators used had been calibrated at their normal specified interval. If a test duration were to exceed the specified interval, calibration was done prior to start of the test. Power supplies, drive stands and similar equipment are not subject to a specified calibration schedule. These equipment items are used in conjunction with calibrated instrumentation. Other items not subject to specified calibration intervals have been calibrated by the respective manufacturer or have been used for "coarse" readings only prior to final adjustment or readings with calibrated equipment.

The accuracies of instruments used for the principal measurements are:

- Speed: +/- 50 rpm
- Current: +/- 1.0 percent
- Voltage: +/- 1.0 percent
- Temperature: +/- 4 degrees Fahrenheit

Data was recorded on LAPEC standard test data sheets and, in some cases, on oscillographic traces.

TABLE 5-1

INSTRUMENT IDENTIFICATION LIST

Item	Manufacturer	Model No.	Range	Accuracy
Oscilloscope	Tektronix	2246	-----	Manufacturer's Manual
Multimeter	Fluke	8600A	0-1200 volts	DC ± (0.02% RDG + 0.008% F.S.) AC, (0.2% RDG + 0.04%F
Measurement Plotting System	Hewlett Packard	7090A	0-100 volts	0.15%
DC Ammeter	Weston	901	0-1/2/5 AMPS	0.5% F.S.
DC Ammeter	Weston	931	0-100/200/500 AMPS	0.5% F.S.
DC Ammeter	Weston	430	0-500 AMPS	
DC Voltmeter	Weston	901	0-150/300/750 Volts	0.5% F.S.
DC Voltmeter	Weston	901	0-3/150/300 Volts	0.5% F.S.
Temperature Indicator	Instrulab	2000 Data Logger	0-150 to 1600°F 0-50 Volts DC	± 0.5°F ± 0.05% DC
Frequency Conditioner	Daytronic	3240A	0-1000 Hz	± 0.05% F.S.
Frequency Conditioner	Daytronic	3240	0-1000 Hz	± 0.05% F.S.
Load Bank	Avtron	K593	0-to-400 AMPS IN STEPS 270 Volts DC	

TABLE 5-1
INSTRUMENT IDENTIFICATION LIST

Item	Manufacturer	Model No.	Range	Accuracy
Multimeter	Fluke	25	0-1000 Volts	0.1% DC
Drive Stand	Lucas/PEC	No.: 5	0-35000 RPM	± 50 RPM
Drive Stand	Lucas/PEC	No.: 6	0-35000 RPM	± 50 RPM
Multimeter	Fluke	8840A	0-2000 Volts AC/DC	0.5% AC/DC
Counter/Timer	Anadex	CF-635R	0-99999 Counts	± 1.0 Count
Shunt	Weston	----	500 AMPS to 50 Mv	0.5% F.S.

5.1 <u>Examination of Product</u>

Purpose: The purpose of these examinations are to ensure that the generator, GCU and current sensor met their respective dimensional requirements in accordance with their respective outline drawings.

Procedure: Measurements were made by a qualified representative of LAPEC Q.A. department on two generators, two GCU's, and one current sensor. Results were recorded on standard LAPEC documented layout reports.

Results: Documented layout reports are included in succeeding pages of this report.

Discussion of results: The generators met all of the dimensional requirements but weights exceeded the specification value. A discussion of generator weight has been included in section 3.2 <u>Mechanical Design</u>.

Both GCU's inspected had dimensional discrepancies and exceeded the specification weight of 5 pounds. The dimensional discrepancies are acceptable in view of the fact that both units are prototype (laboratory) units. The increased weights of the units resulted from modifications required following design verification testing. Based on today's technology, the GCU specification weight and dimensions can be met.

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Vendor/Dept. No. 534/902

~~BO/P.O.~~ 54807 ENI ~~R. B. No.~~ 21498

Qty. Rec'd 1 Inspector LES

Date Rec'd 6-7-1988

Part No. 30527-000 Dwg Issue C

Name GENERATOR

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	13.06 DIM.	MAX.	12.9350	✓		
2	6.88 DIM.	MAX.	6.860	✓		
3	6.805 DIM.	MAX.	6.792	✓		
4	7.44 DIM.	MAX.	7.374	✓		
5	6.88 RAD	MAX.	6.810	✓		
6	6.19 RAD	MAX.	6.050	✓		
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APPR | REJECTED

Supervisor / / Date Signed Engineer / / 19 Date

FORM 4080 B (9/87)

USE BALLPOINT PEN—WRITE FIRMLY

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation
DOCUMENTED LAYOUT REPORT

Vendor/Dept. No. 902
Part No. 30527-0000 Dwg. Issue C
EWO 54807 EWI 26498
Name GENERATOR
Qty. Rec'd 1 Inspector LES Q.
#101
Date Rec'd 7-1 19 88 (QA 355)

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	13.06 DIM.	MAX.	12.962	✓		
2	6.88 DIM.	MAX	6.870	✓		
3	6.805 DIM.	MAX.	6.798	✓		
4	7.44 DIM.	MAX.	7.387	✓		
5	6.88 RAD.	MAX.	6.840	✓		
6	6.19 RAD.	MAX.	6.075	✓		
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Supervisor ___ Date / / ___ Signed ___ Engineer ___ Date / / 19 ___

FORM 4080 B (9/87)

USE BALLPOINT PEN—WRITE FIRMLY

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Vendor/Dept. No. 930

PO/PJO 54808 R. R. No. SL 120

Qty. Rec'd 1 Inspector [illegible] (368)

Date Rec'd May 25 19 88

Part No. 30527 0906 Dwg Issue Ø

Name DC Current Sensor

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN	ACC	REJ	REMARKS
1	[illegible] Dia		.057	✓		
2	3/4 Dia		.750	✓		
3	17 Dia		.169	✓		4 Places
4	1 5/8 Dia		1.625	✓		
5	2 7/8 Dia		2.880	✓		
6	1 3/16 Dia		1.190	✓		
7	1 5/8 Dia		1.622	✓		
8	2 Dia		2.00	✓		
9	2 Dia		2.00	✓		
10	2 9/16 Dia		2570	✓		
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Disposition 1

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Supervisor Date / / Signed Engineer Date / / 19

FORM 4080 B (9/87)

USE BALLPOINT PEN—WRITE FIRMLY

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Dept. No. 930

PO/PJO 54808 R. R. No. S/L 103

Qty Rec'd 1 Inspector Marx

Date Rec'd May 25 1988

Part No. 51527 0000 Dwg Issue Ø

Name G.C.U.

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	9.63 Dim	Max.	9.635		X	
2	8.50 Dim	Max	8.510		X	
3	9.80 Dim	Max.	9.715	✓		
4	4.76 Dim	Max	4.750	✓		
5	57 - 55	Dim	.575		X	
6	.38 - 37	Dim	375	✓		
7	25 - 24	Dim	.260	✓		
8	213 - 203	Dia	.300		X	4 Places Plant in Holes
9	098 - 086	Dim	.090	✓		
10	3.75 Dim	Max.	3.730	✓		
11	2.94 - 284	Dim	2.880	✓		
	2.72 - 262	Dim	2.665	✓		
13	5.72 Dim	Max	5.630	✓		
14	560 Dim	Max.	5.575	✓		
15	3.55 - 3.45	Dim	3.490	✓		
16	1.67 - 1.57	Dim	1.605	✓		
17	Note #3	Max	5.75#		X	
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Disposition 1

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Supervisor / / Date Signed: Engineer / / 19 Date

USE BALLPOINT PEN—WRITE FIRMLY

FORM 4080 R (9/87)

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Dept. No 940 | Part No. 51527-000 | Dwg Issue ∅

EWO 54808 | EWE 2497 | Name GENERATOR CONTROL UNIT

Qty. Rec'd 1 | Inspector LES | S/N 104

Date Rec'd 6-8 19 88

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	9.63 DIM.	MAX.	9.617/9.618	✓		
2	9.120 DIM.	±.01	9.117/9.127	✓		
3	.24/.25 DIM.	—	.244/.246	✓		
4	4.76 DIM.	MAX.	4.753/4.750	✓		
5	4.00 DIM.	±.01	3.997/4.001	✓		
6	.37/.38 DIM.	—	.370/.378	✓		
7	.55/.57 DIM.	—	.555/.568	✓		
8	9.80 DIM.	MAX.	9.746/9.750	✓		
9	8.50 DIM.	MAX.	8.485/8.497	✓		
10	.203/.213 DIA.	—	.203/.207	✓		(4) MOUNTING HOLES
11	.086/.098 DIM.	—	.087/.088	✓		
	5.72 DIM.	MAX.	5.620/5.630	✓		
13	5.60 DIM.	MAX.	5.410/5.420	✓		
14	3.45/3.55 DIM.	—	3.405/3.410		✓	
15	1.57/1.67 DIM.	—	1.518/1.520		✓	
16	3.75 DIM.	MAX.	3.686/3.692	✓		
17	2.62/2.72 DIM.	—	2.651/2.653	✓		
18	2.84/2.94 DIM.	—	2.867/2.870	✓		
19	5 NOTE (3) 5 LBS	—	5.65		✓	
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Disposition: 1 ______
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APPR | REJECTED ______ / / ______ Signed: ______ / / 19 ______

Supervisor Date Engineer Date

USE BALLPOINT PEN—WRITE FIRMLY

FORM 4080 B (9/87)

5.2 <u>Overload</u>

Purpose: The purpose of this test was to demonstrate the system's ability to deliver 125% of rated load (208 amperes) for two minutes and maintain voltage regulation within 270 $\pm$ 10 volts.

Procedure: The system was connected as shown in Figure 5-1. The generator was operated at rated load (167 amperes) 16,000 rpm until stabilized temperatures were reached. A load of 41 amperes was added and operation maintained for two minutes.

Results: Test results are recorded on data sheet 21284 and chart 21284-A. Oil inlet temperature was 124.4 degrees Fahrenheit. Stator winding temperatures rose from a 333 degrees to a maximum of 454.9 degrees. The voltage was maintained at 263 volts during the overload.

Discussion of Results: The system met the requirements by a comfortable margin. The temperatures and output voltages were well within the limits ordinarily set for winding temperature and the specified voltage regulation.

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY, TEST RECORD

W.O. 54805 MODEL NO. SYSTEM 2 SERIAL NO. GCU 103 / CURRENT 326; GEN 121 / SENSORS 128 COG. ENGR. HARMAT / De[illegible]K

ROTOR NO. STATOR NO.

ATE OF TEST 6/9/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

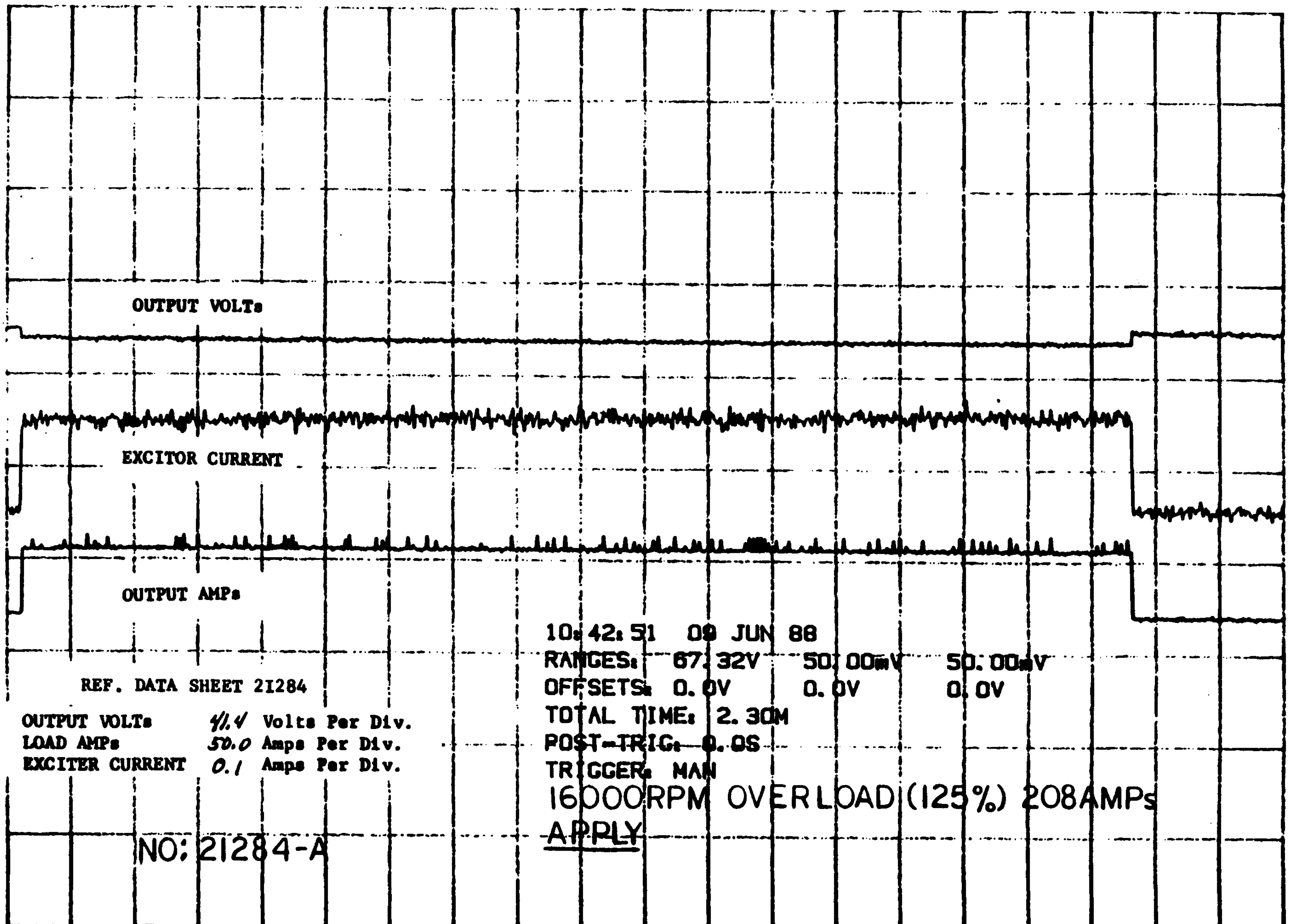
RUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

ITLE: OVERLOAD PAGE OF

PARA. NO. / RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R	OUTPUT AMP LOAD	EXCITOR AMP	EXCITOR VOLT	TEMP °F OIL IN	OIL OUT	STATOR #1	STATOR #2	GEN CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE -	CHART NO:	
																				6.5
6000	10.07	76.9	262.8	169	0.441	79	112.4	151.8	284.9	282.1	146.0	123.9	7.0	10.0	555	3.2	2.2	4.1		
6000	1010	77.1	267.5	169	0.449	83.5	117.5	159.9	314.9	315.9	152.8	129.4	7.0	11.0	580	3.36	2.2	4.0		6.0
6000	1015	78.1	267.3	169	0.45	85.3	122.1	166.3	328.0	332.2	157.9	134.6	7.0	11.0	590	3.42	2.2	4.0		5.5
6000	1020	80.0	267.3	169	0.451	86.0	123.2	167.7	328.2	333.7	159.4	135.3	7.0	11.0	591	3.42	2.2	4.0		5.2
6000	1025	80.9	267.4	168	0.451	86.0	123.7	168.3	328.9	333.3	161.4	132.9	7.0	11.0	610	3.53	2.2	4.0		5.1
		SYSTEM STABILIZED – 2 MIN OVERLOAD																		5.1
5960	1038	80.0	263.0	206	0.555	107.1	124.1	169.4	422.0	399.1	163.1	132.5	7.0	11.0	610	3.53				
5960	1038	80.0	262.8	205	0.58	110.0	124.7	171.2	454.9	452.8	165.1	132.1	7.0	11.0	615	3.56	2.0	4.1		
6000	1041	80.1	267.4	169	0.452	92.0	126.6	172.3	425.2	422.5	164.1	139.3	7.0	11.0	610	3.52	2.2	4.0		5.5

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG.

NO: 21284


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 21284
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
NO: 21284-A
10:42:51 09 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 2.30M
POST-TRIG: 0.0S
TRIGGER: MAN
16000RPM OVERLOAD (125%) 208AMPs
APPLY

5.3 Voltage Regulation and Transient Response

Purposes: The purposes of these tests were to demonstrate the system's ability to meet the voltage regulation and transient response requirements specified.

Procedure: The generator was operated at 9,000, 16,000 and 18,000 rpm. At each of these speeds, loads of 25, 50, 75 and 100 percent were applied and removed.

Results: Test results are recorded on data sheet 22747 and charts 1 through 8 for 9,000 rpm; data sheet 22744 and charts 1 through 8 for 16,000 rpm; data sheet 22748 and charts 1 through 8 for 18,000 rpm. A summary of the transient data is shown in Table 5-2.

Discussion of Results: Throughout the speed and load ranges, the voltage at the point of regulation (POR) changed by a total of 8 volts. Specification allows +/- 5.0 volts (total of 10V) only. Since the regulator characteristic is such that the POR voltage droops when load is applied the no-load setting could be moved to 274 volts and with the 8 volts maximum drop the POR voltage would be 266 volts and meeting 270 +/- 5 VDC regulation limits.

The load transients (application and removal) voltages and recovery times are summarized in Table 5-2. Recovery times are met under various speed and load conditions, except at low speed (9,000 RPM) under 75 and 100 percent loads. The total closed loop gain of the system required compensation (reduction) at higher speeds to achieve stability. Therefore, this compensation affects the transient response at low speeds where the system gain is much lower. Preliminary studies indicate, that a speed feedback could help, bringing the low speed transient response closer to specification limits.

5.4 Voltage Ripple

Purpose: The purpose of this test was to demonstrate that the ripple voltage was equal or less than that required by the specification.

Procedure: This test was done simultaneously with the voltage regulation test, paragraph 5.3 above.

Results: Test results are recorded on data sheets 22744, 22747, and 22748. appended to the voltage regulation test.

Discussion of Results: The test results showed that at all conditions of load and speed, the voltage ripple was less than the 12 volts required by the specification.

TABLE 5-2

Summary of Transient Performance Test Results

RPM	% Load	Application Minimum Voltage	Application Recovery (Seconds)	Removal Maximum Voltage	Removal Recovery (Seconds)
9,000	100	223	0.077	305	0.070
9,000	75	236	0.040	289	0.030
9,000	50	219	0.022	279	0.022
9,000	25	249	0.010	*	*
16,000	100	214	0.024	307	0.030
16,000	75	208	0.006	290	0.028
16,000	50	255	0.014	282	0.024
16,000	25	260	0.011	*	*
18,000	100	217	0.032	305	0.040
18,000	75	248	0.012	291	0.024
18,000	50	231	0.016	281	0.020
18,000	25	257	0.020	*	*

* Does not exceed voltage regulation limits

NOTE: Specification requires for load application and removal, minimum voltage of 175 volts, maximum voltage of 350 volts, and recovery time of 0.033 second.

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 2 SERIAL NO. GCU 103 / CURRENT 326, GEN 182 / SENSORS 123 COG. ENGR. Harmat/Dev. LLK

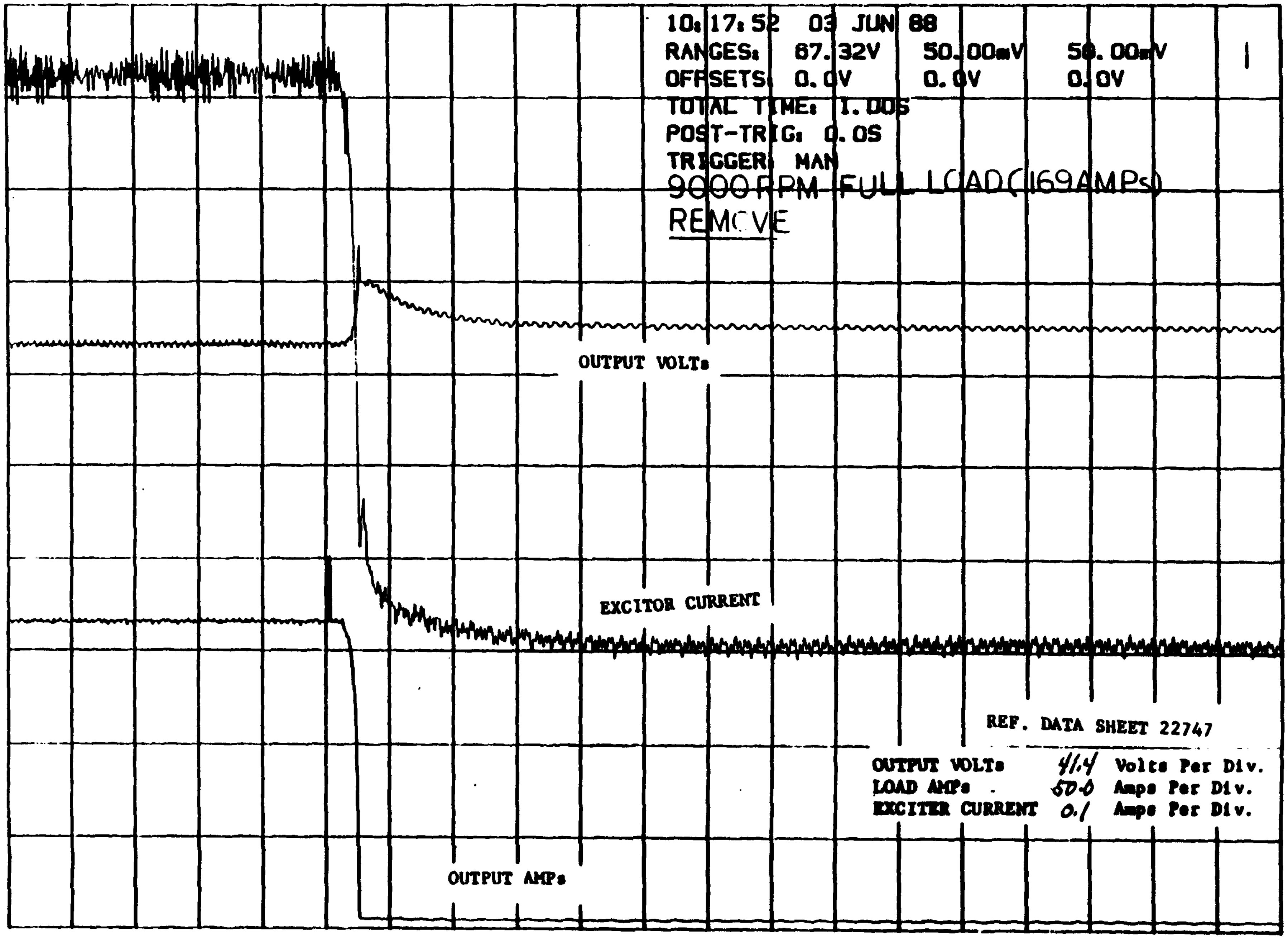
ROTOR NO. STATOR NO.

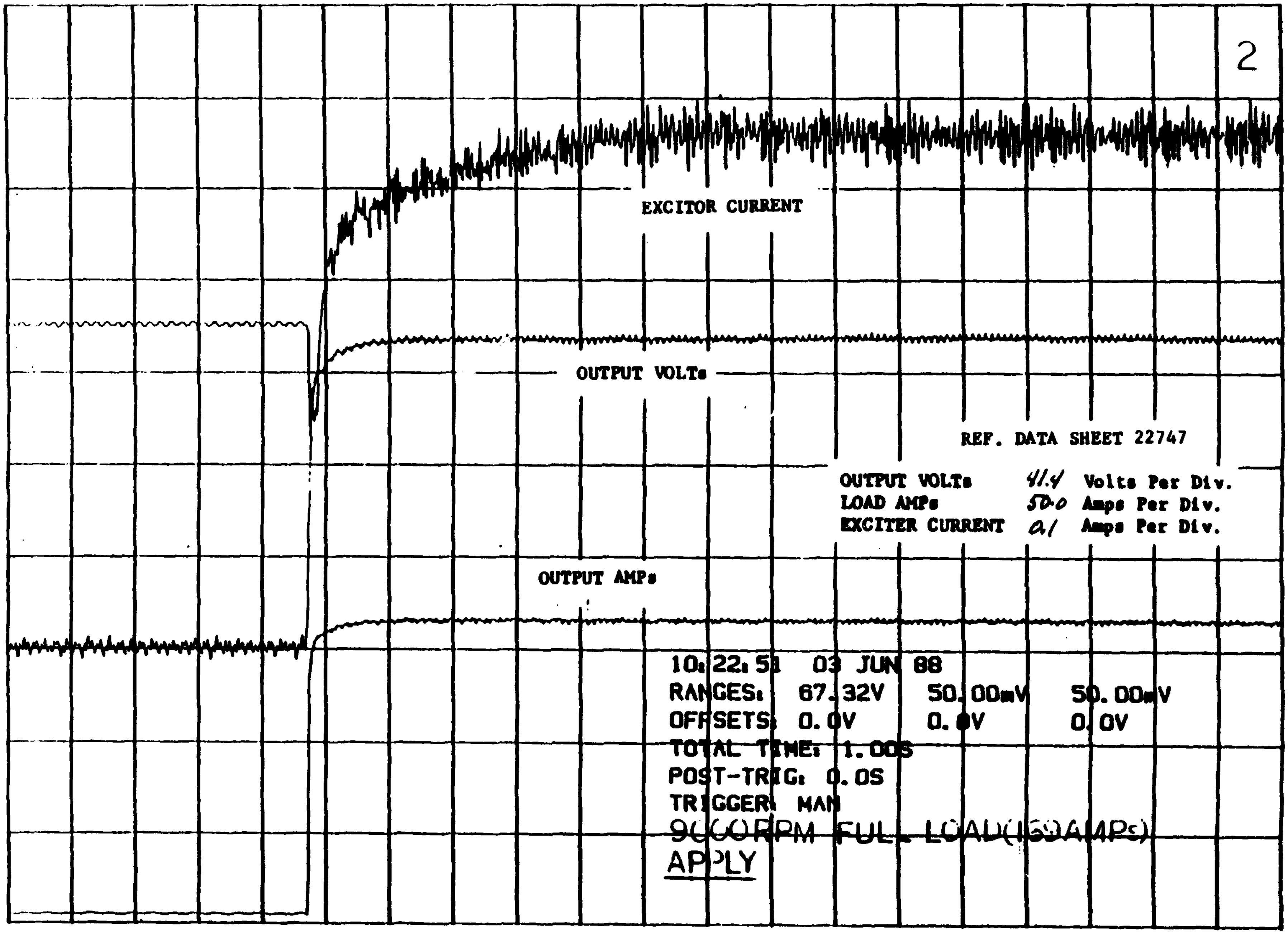
DATE OF TEST 6/3/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

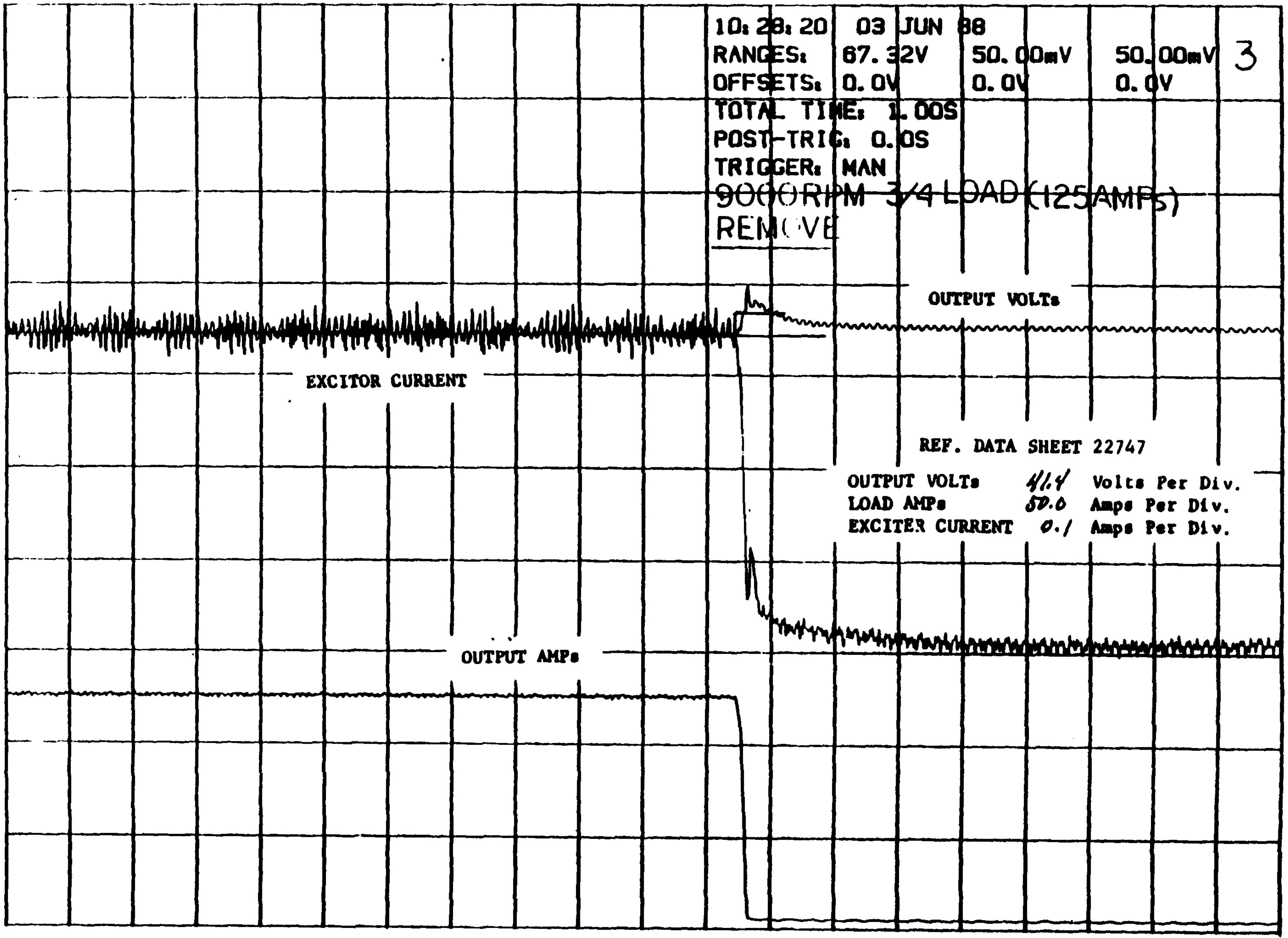
TITLE: VOLTAGE REGULATION STABLE LLK TEST 9000RPM PAGE 2 OF 3 65

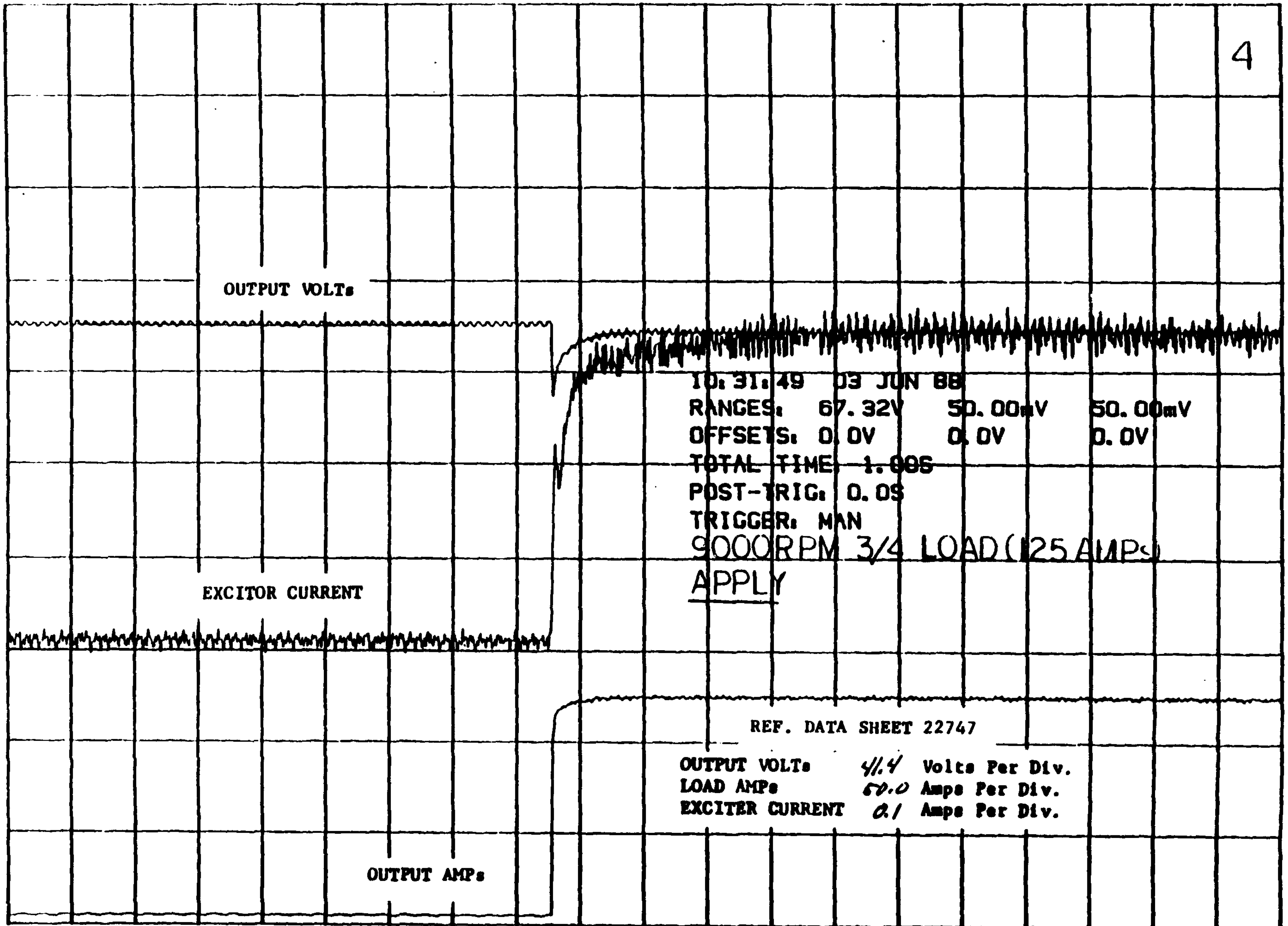
RPM	TIME	AMB. TEMP.	OUTPUT VOLT POR	OUTPUT AMP	EXCITOR AMP		TEMP °F OIL IN	OIL OUT	STATOR A1	STATOR #2	CASE	GEN AIR	OIL IN	PRESSURE OUT	OIL CYCLES	GAL PER MIN		RIPPLE +	RIPPLE −	CHAN NO.	
16000	0945	75.1	268.1	168	0.44		105.1	142.5	316.8	300.2	141.4	122.3	7.0	10.5	580	3.07		3.0	4.0		7.8
16000	0951	77.8	267.1	169	0.445		118.1	161.7	381.1	373.3	157.2	137.6	7.0	11.0	585	3.39		2.5	4.0		6.0
16000	0959	78.9	267.0	169	0.446		121.9	166.7	393.9	388.1	161.5	142.1	7.0	11.5	590	3.42		2.0	4.0		6.9
16000	1005	79.8	267.1	169	0.45		122.1	167.1	395.0	389.6	162.1	142.7	7.0	11.5	594	3.43		2.0	4.0		5.5
16025	1010	80.5	267.1	169	0.45		122.3	167.3	394.5	389.4	162.1	143.2	7.0	11.5	595	3.44		2.0	4.0		5.5
9050	1011	80.5	261.0	165	0.92		122.3	167.3	394.4	389.2	162.0	143.2	7.0	11.5							
9050	1014	81.0	267.9	0	0.3		115.2	154.8	347.6	367.5	153.5	136.9	7.0	11.0							
9050	1018	81.0	263.9	166	0.88		109.2	146.7	328.8	387.9	147.1	128.9	7.0	11.0						1	
9000	1023	81.0	265.5	125	0.64		102.8	136.8	278.0	276.8	137.7	124.1	7.0	11.0						2	
8800	1024	80.9	268.2	0	0.31		101.3	135.0	269.3	272.7	135.9	118.4	7.0	11.0	419	3.43		4.0	4.0		6.1
9000	1027	80.6	266.6	125	0.63		97.2	129.7	258.0	251.6	131.2	118.5	7.0	11.0				2.0	2.0	3	
9060	1032	80.6	266.4	85	0.485		95.3	126.0	218.1	219.2	126.9	111.3	7.0	11.0	415	2.4		4.0	4.0	4	6.0
9260	1035	80.4	268.0	0	0.31		91.5	119.9	186.2	183.8	120.7	107.2	7.0	11.0				3.5	4.0		5.0
9050	1038	80.7	266.5	85	0.48		91.1	119.7	197.8	196.2	121.5	106.5	7.0	11.0				2.0	2.0	5	3.0
9000	1043	80.7	266.5	42	0.38		89.7	116.9	176.1	172.9	117.8	104.7	7.0	11.0				4.0	4.0	6	6.7
9150	1044	80.1	269.2	0	0.312		89.0	115.7	164.3	166.5	116.4	103.8	7.0	11.0				3.0	4.0		4.6
9000	1048	80.0	266.7	42	0.325		80.0	112.7	157.7	157.2	114.0	101.6	7.0	11.0				2.0	2.0	7	2.9
																		3.0	4.0	8	4.6


10:17:52 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000 RPM FULL LOAD (169 AMPs)
REMOVE
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

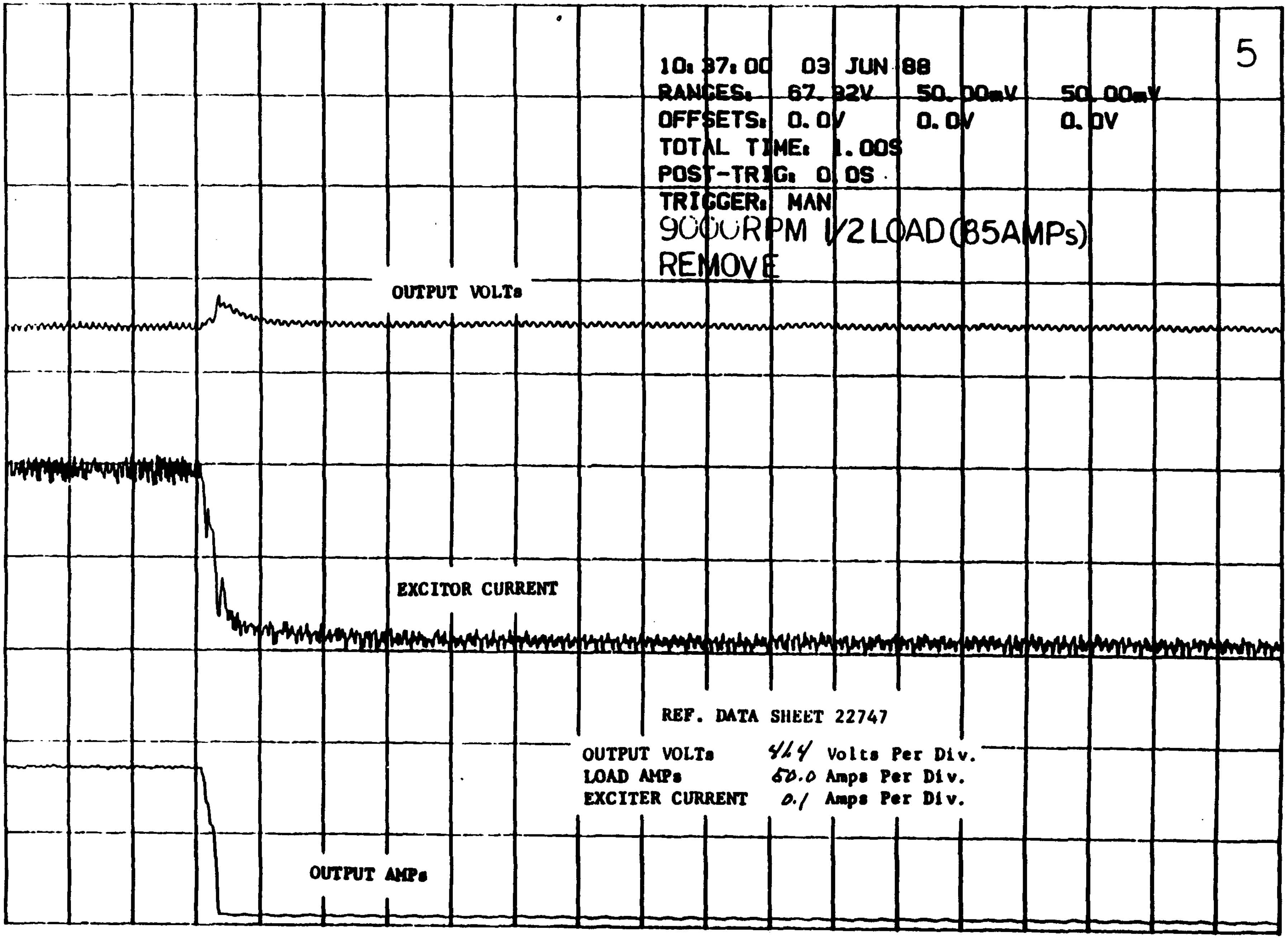


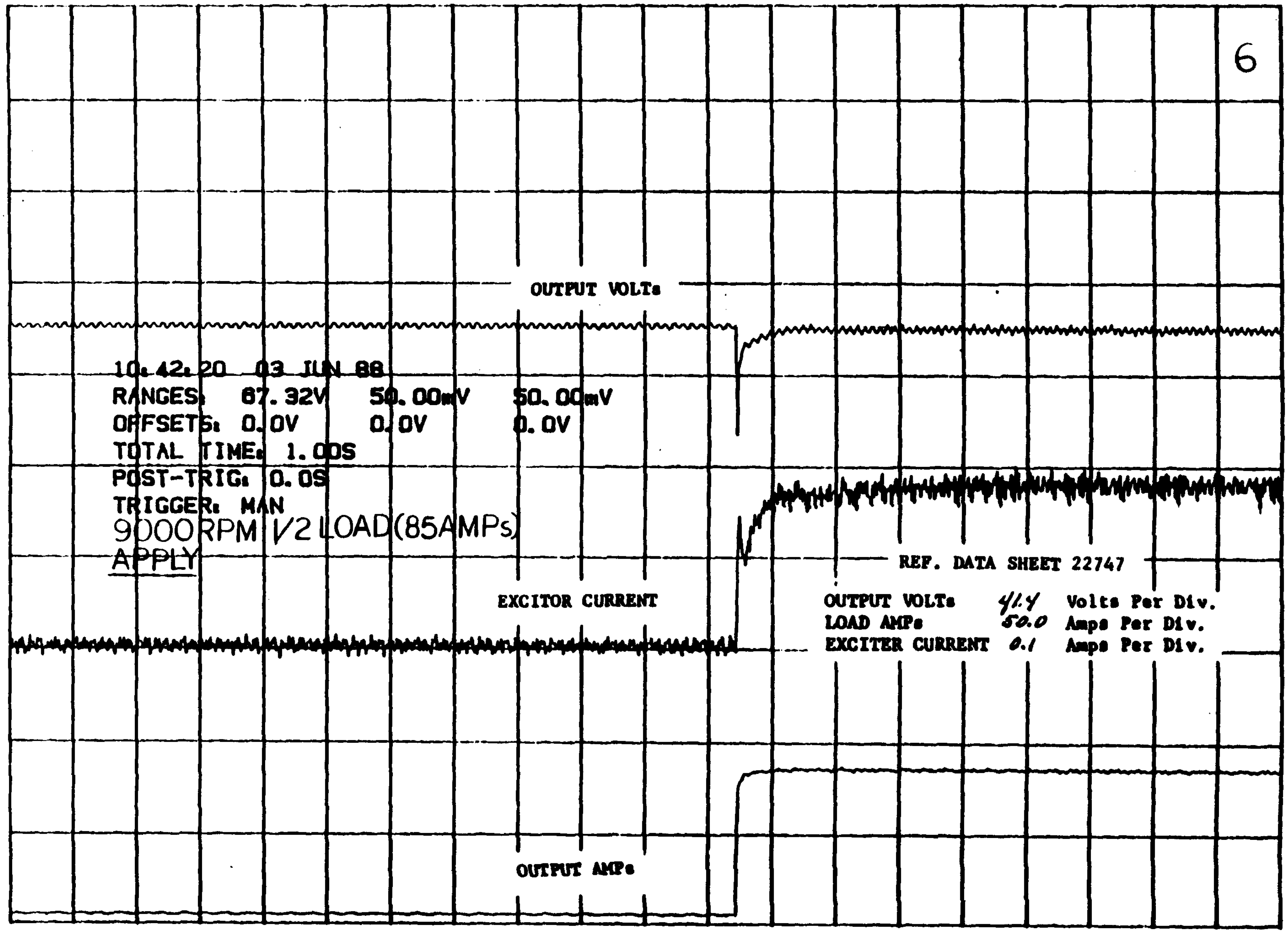
2
EXCITOR CURRENT
OUTPUT VOLTs
OUTPUT AMPs
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
10:22:51 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM FULL LOAD(150AMPs)
APPLY

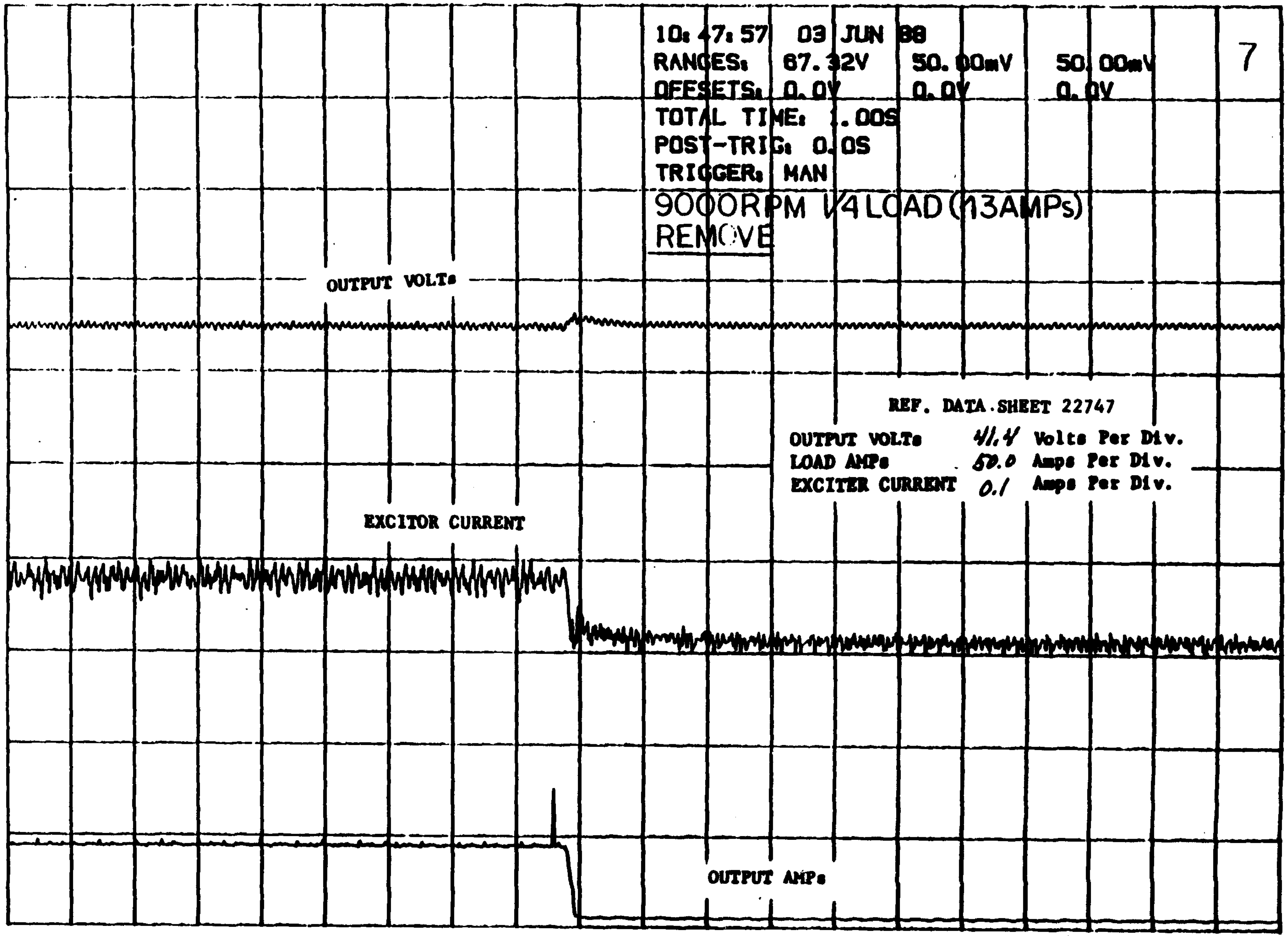

10:28:20 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM 3/4 LOAD (125AMPs)
REMOVE
3
OUTPUT VOLTs
EXCITOR CURRENT
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
OUTPUT AMPs



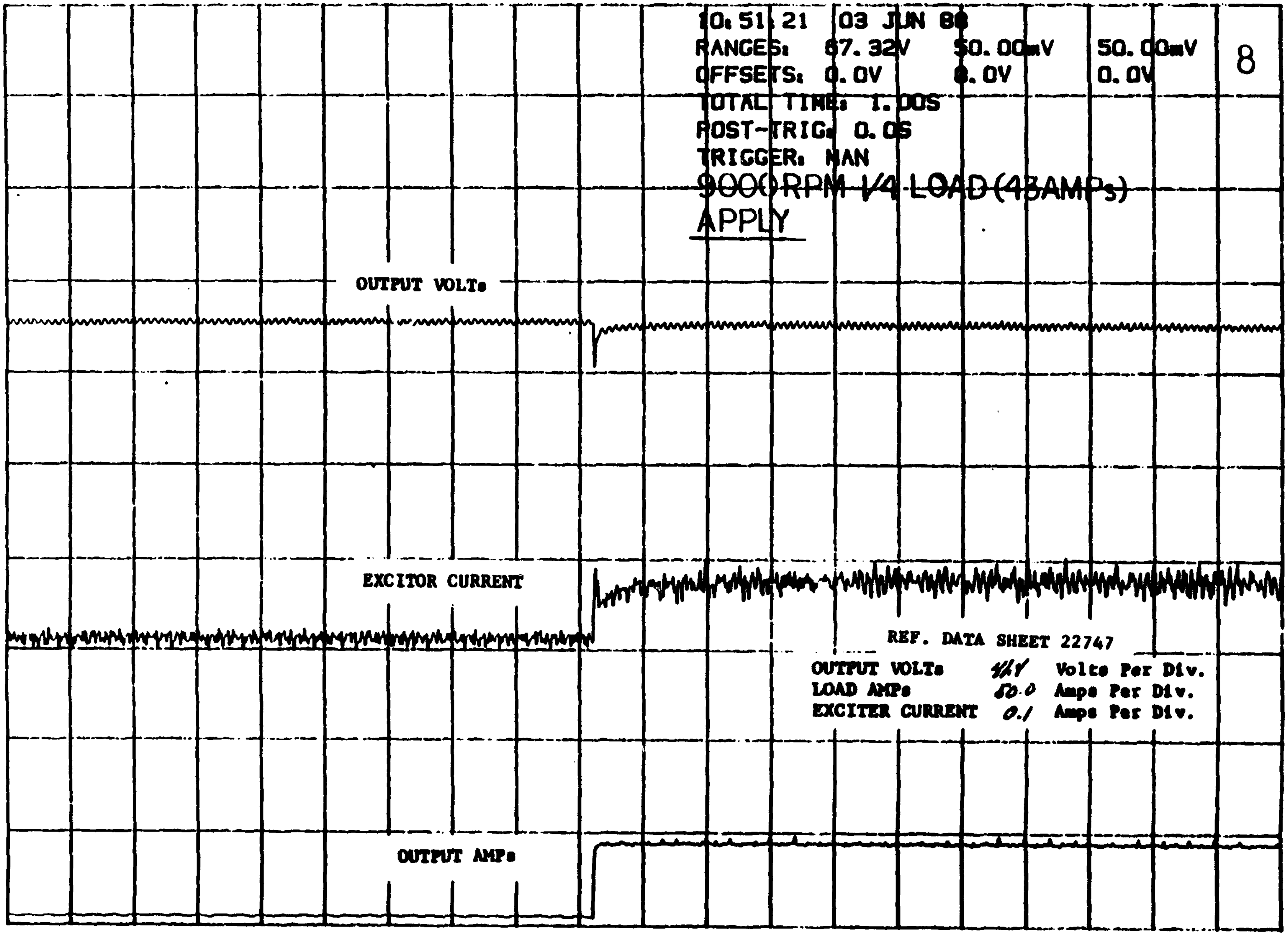
4
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
10:31:49 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM 3/4 LOAD (125 AMPs)
APPLY
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.


5
10:37:00 03 JUN 88
RANGES: 67.92V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM 1/2 LOAD (85AMPs)
REMOVE
OUTPUT VOLTs
EXCITOR CURRENT
REF. DATA SHEET 22747
OUTPUT VOLTs 4.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
OUTPUT AMPs


6
OUTPUT VOLTs
10:42:20 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM 1/2 LOAD(85AMPs)
APPLY
EXCITOR CURRENT
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
OUTPUT AMPs



10:47:57 03 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000RPM 1/4 LOAD (13AMPs)
REMOVE
7
OUTPUT VOLTs
REF. DATA SHEET 22747
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs


10:51:21 03 JUN 88
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
9000 RPM 1/4 LOAD (43AMPs)
APPLY
8
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22747
OUTPUT VOLTs 4.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

HAMILTON STANDARD (?)

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 2 SERIAL NO. GCU 103 / CURRENT 326, GEN 101 / SENSOR 123 COG. ENGR. Harmat / Dere...

ROTOR NO. STATOR NO.

DATE OF TEST 5/31/88 TEST LETTER: NO. QP 387 TESTED BY R.J. SANIUK

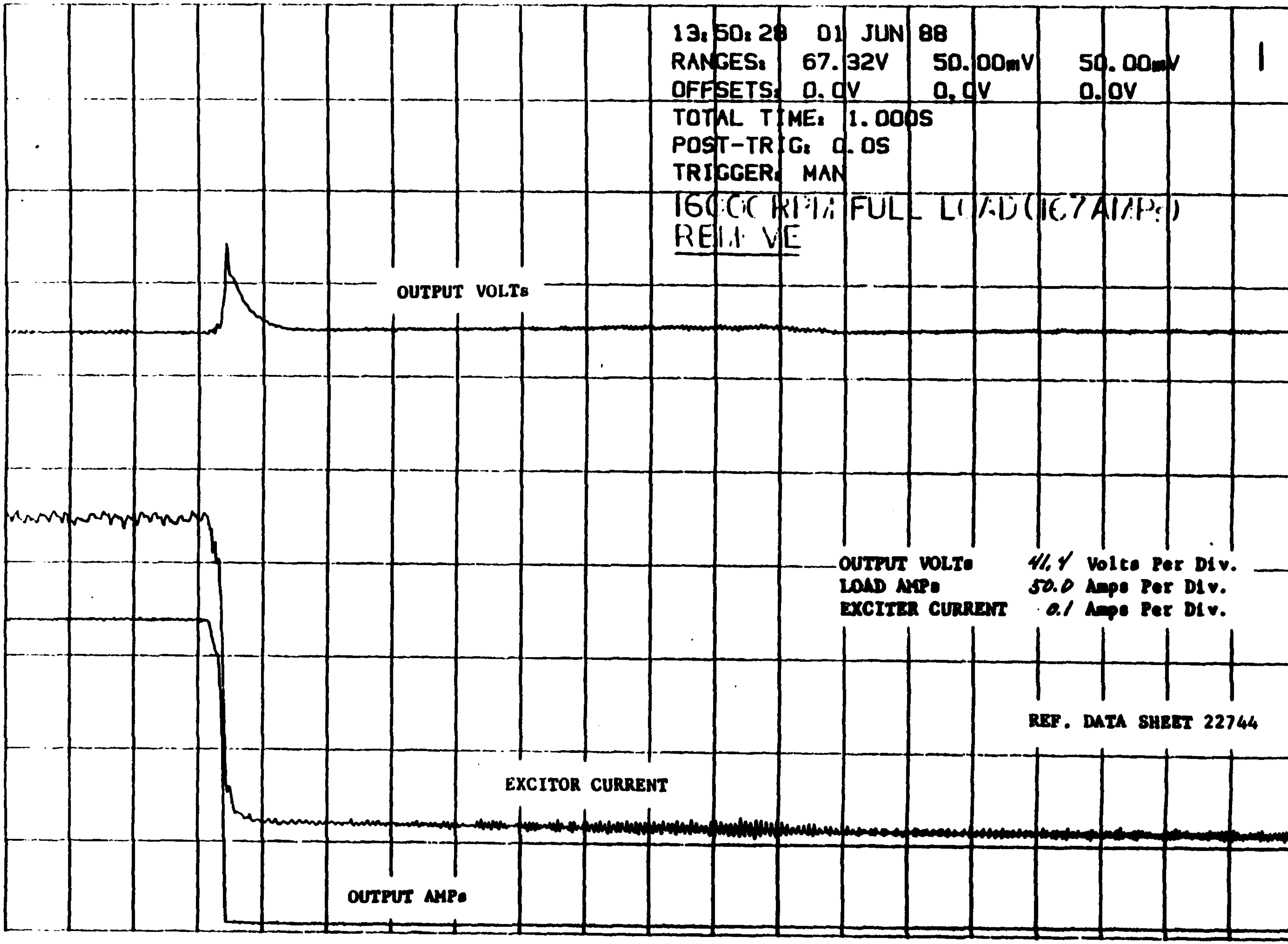
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

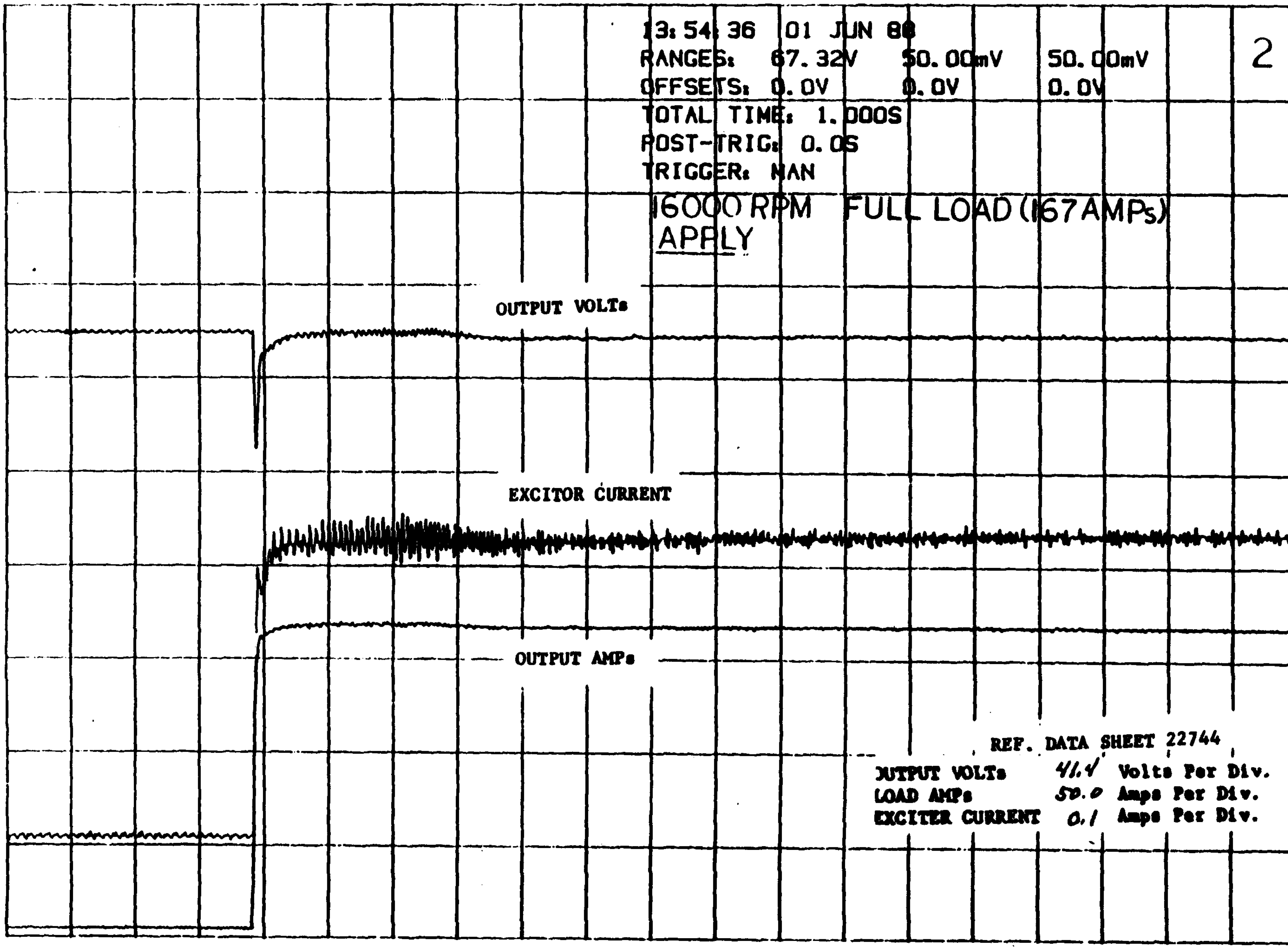
TITLE: VOLTAGE REGULATION. 16000 RPM PAGE 1 OF 3 GS

RPM	TIME	AMB. TEMP.	OUTPUT VOLTS POR	OUTPUT AMP	EXCITOR AMP		OIL IN (TEMP °F)	OIL OUT (TEMP °F)	STATOR #1 (TEMP °F)	STATOR #2 (TEMP °F)	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLE	GAL PER MIN	CASE TEMP	GEAR BOX TEMP		RIPPLE +	RIPPLE −	GRAPH NO.	
16005	1317	84.9	267.5	168	0.439		97.8	132.6	279.2	255.1	8.0	10.5	504	2.918	136.2	119.9		2.0	4.0		6.5
16025	1327	88.3	266.1	168	0.445		124.3	168.6	395.2	391.0	8.0	11.5	590.	3.42	169.8	149.2		2.0	4.0		6.4
16015	1335	89.8	265.9	168	0.445		126.3	171.3	405.9	398.6	8.0	12.0	610	3.53	172.9	151.7		2.0	4.0		6.6
16015	1340	90.8	265.9	168	0.445		126.8	172.2	403.3	396.9	8.0	12.0	615	3.56	172.3	154.2		2.0	3.5		6.5
16005	1345	91.4	266.0	168	0.445		126.7	172.0	401.5	390.0	8.0	12.0	615	3.56	173.2	153.0		2.0	3.5		6.6
17255	1347	91.9	267.6	0	0.11		126.8	172.1	393.5	391.4					173.6	152.5				1	A
16065	1352	92.5	266.6	168	0.445		126.3	171.8	391.3	389.5					172.3	152.5		2.0	3.5	2	6.0 R
17815	1355	92.3	267.6	0	0.11		121.9	168.9	295.2	301.7					163.6	147.7				3	5.5
	1402	92.3	266.1	125	0.11		115.3	155.8	279.9	279.7					156.8	141.6				4	
16650	1409	92.8	265.8	84	0.25		113.1	154.9	243.4	247.5	7.0	10.5	560	3.24	152.1	138.6		1.5	2.0		5.5
16620	1412	92.2	267.8	0	0.115		109.3	146.7	196.1	202.3					144.8	134.9		1.5	1.5	5	[illegible]
16070	1415	91.6	266.0	84	0.25		105.3	138.9	177.1	176.2			545	3.16	132.0	131.1				6	6
16025	1419	92.1	265.3	43	0.171		105.3	140.5	193.2	195.5	6.0	10.0	540	3.13	144.3	130.7		1.0	2.0		5.8
16260	1421	92.1	267.9	0	0.12		104.3	138.9	182.6	183.1					138.4	129.9		1.5	1.5	7	
16065	1426	91.9	265.3	43	0.171		103.0	136.7	175.9	175.5	6.0	10.0	530	3.07	136.5	127.7		1.0	2.0	8	5.8

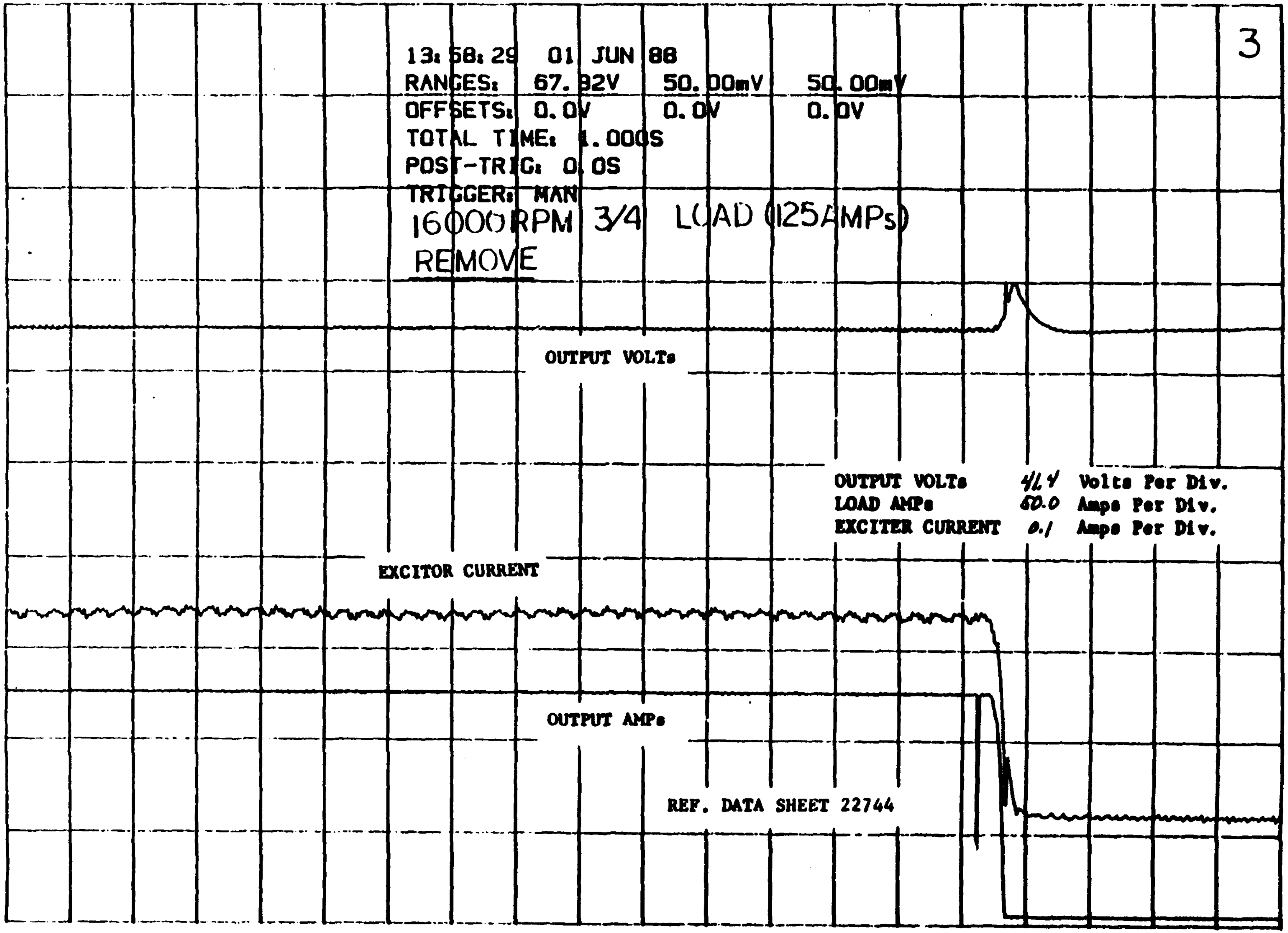
COX OIL FLOW METER 1761
K FACTOR CYCLES ÷ 172.72
= GAL PER MIN.

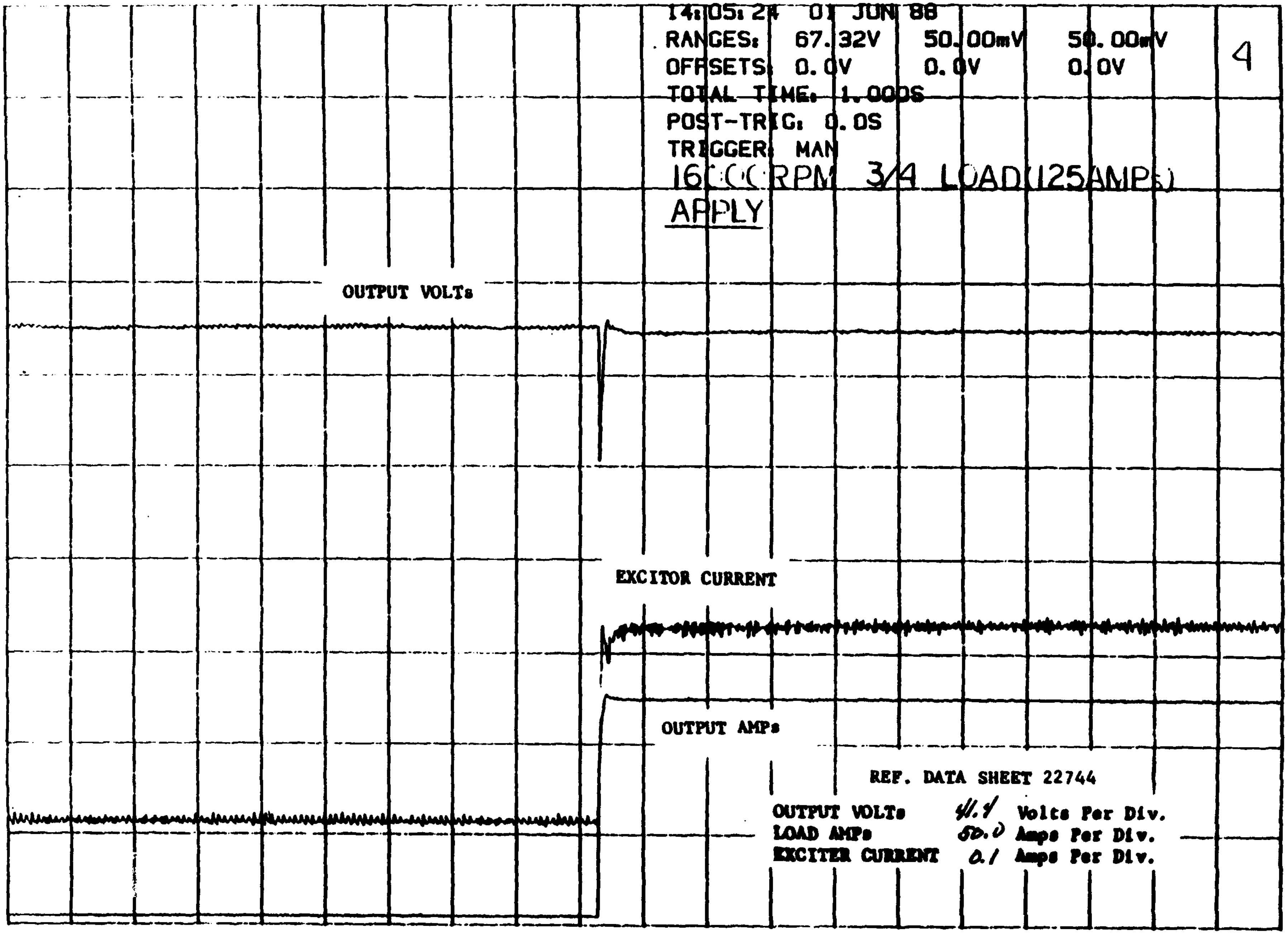
FORM 1349 8/3 (12/62) PRECEEDING PAGE NO. ____ FOLLOWING PAGE NO.


13:50:28 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
1600 RPM FULL LOAD (167 AMPS)
RELIEVE
1
OUTPUT VOLTs
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
REF. DATA SHEET 22744
EXCITOR CURRENT
OUTPUT AMPs

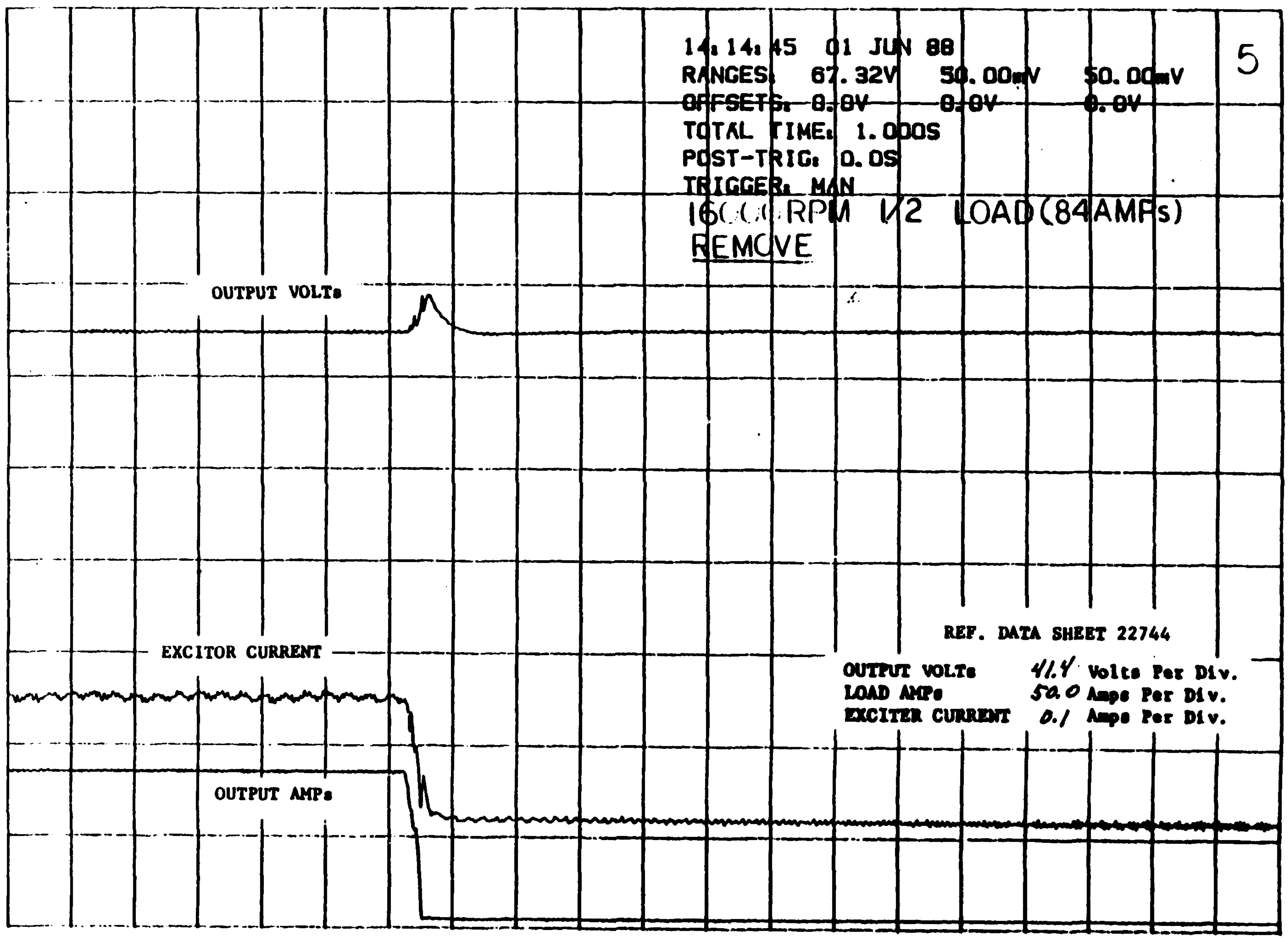


13:54:36 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
16000 RPM FULL LOAD (167 AMPs)
APPLY
2
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22744
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

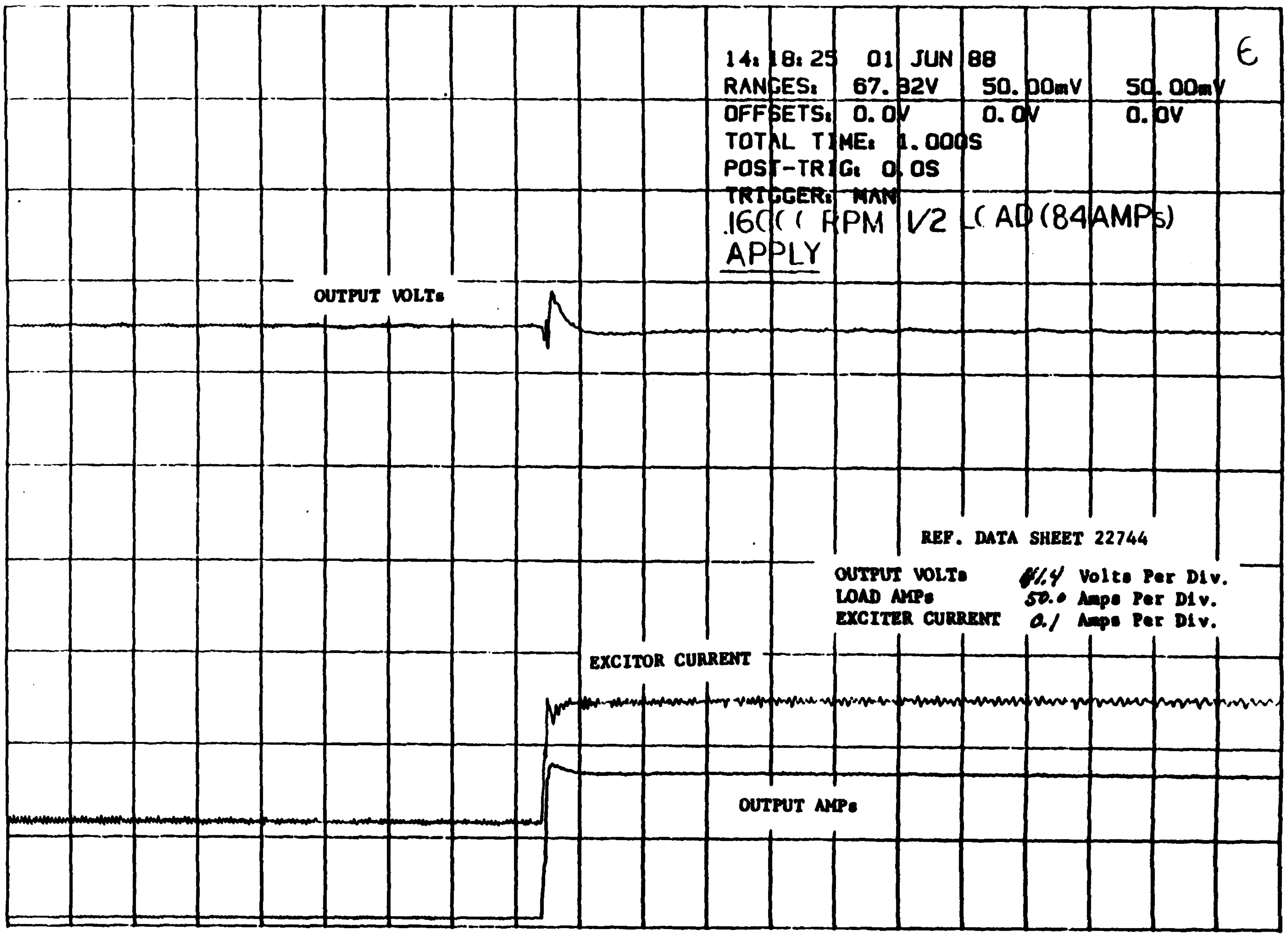

3
13:58:29 01 JUN 88
RANGES: 67.92V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
16000 RPM 3/4 LOAD (125 AMPs)
REMOVE
OUTPUT VOLTs
OUTPUT VOLTs 4/.4 Volts Per Div.
LOAD AMPs 60.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22744

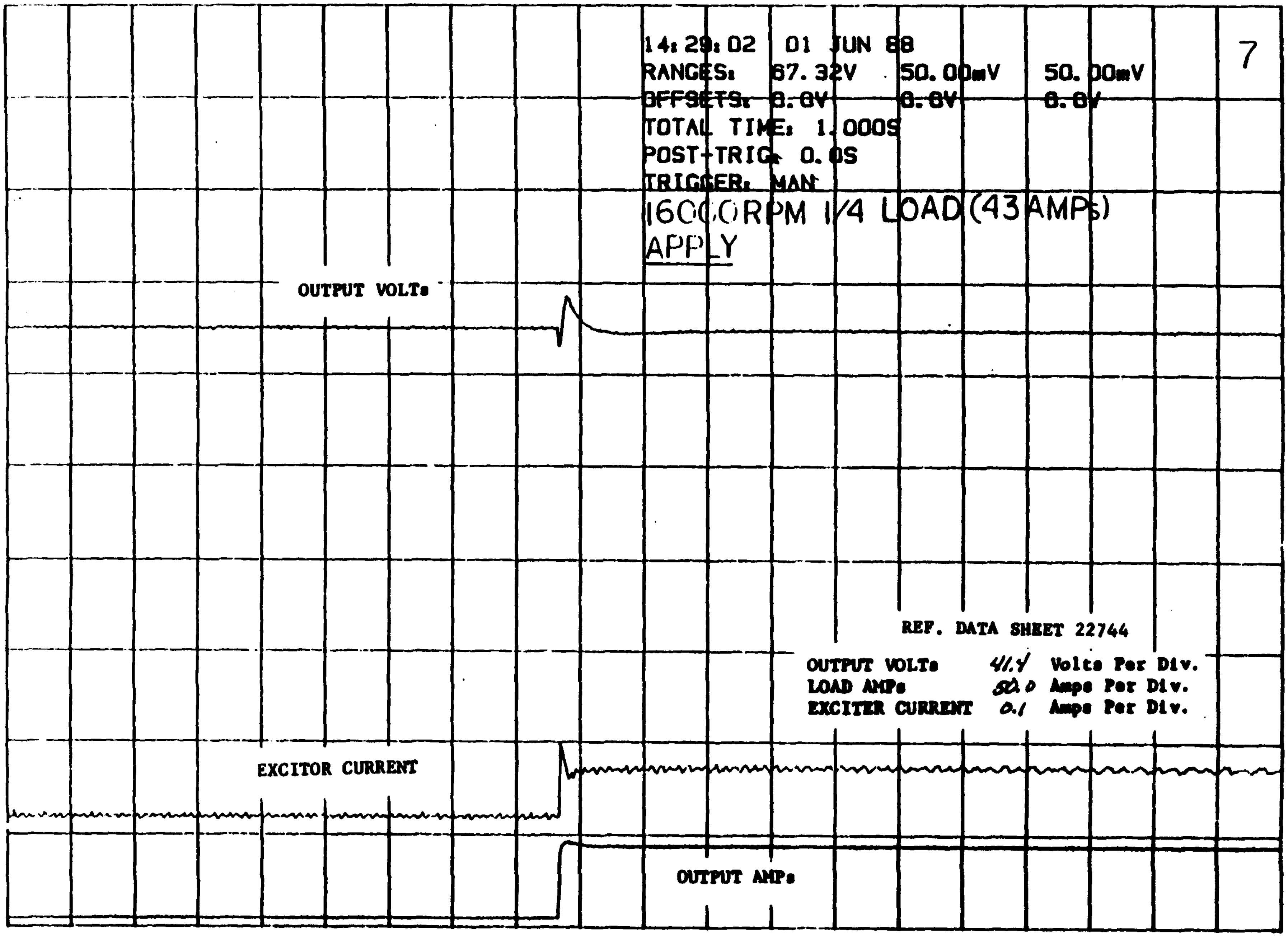


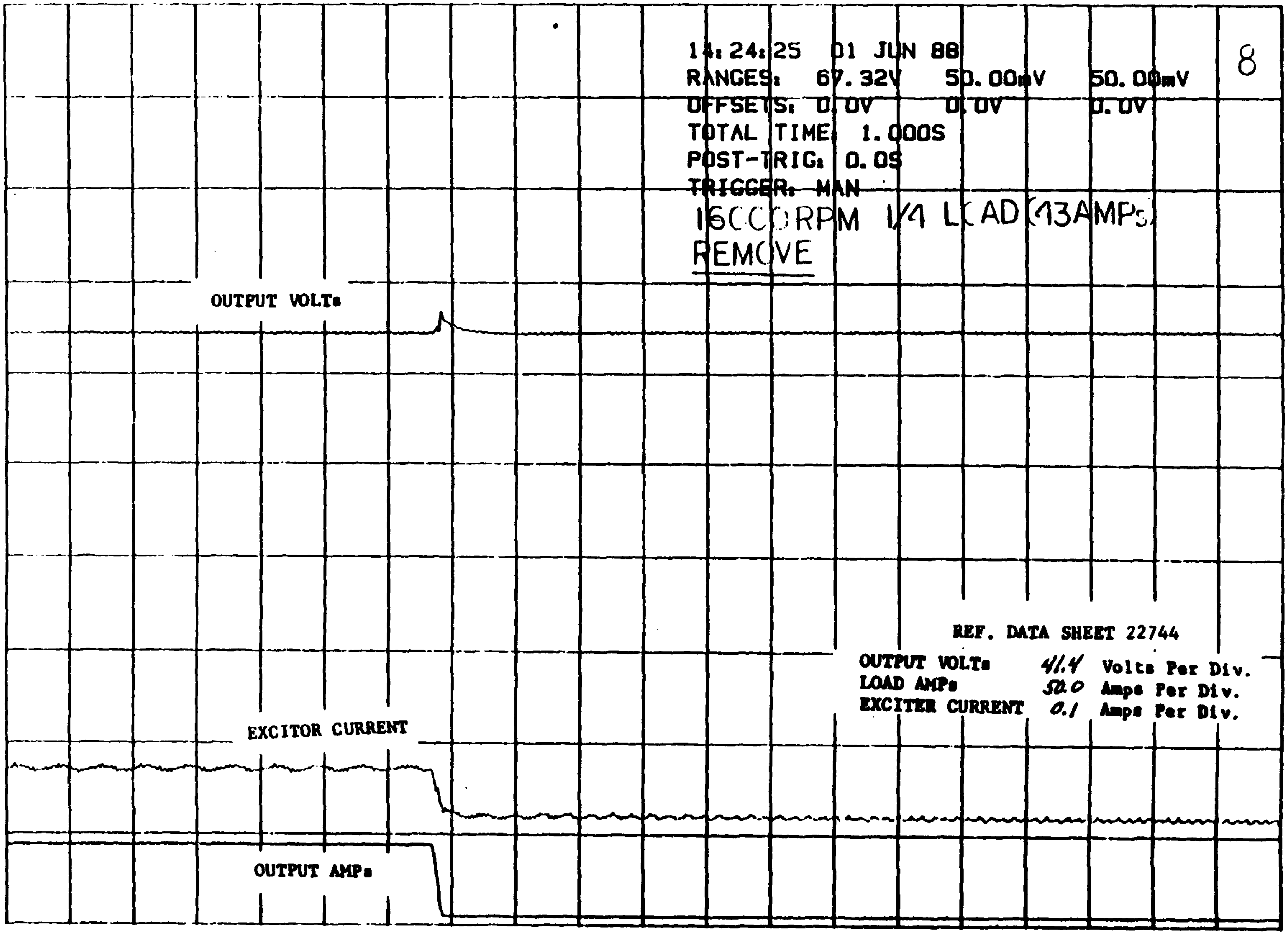
4
14:05:24 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
1600RPM 3/4 LOAD(125AMPS)
APPLY
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22744
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.



5
14:14:45 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
16000 RPM 1/2 LOAD (84AMPs)
REMOVE
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22744
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.


6
14:18:25 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
16000 RPM 1/2 LOAD (84 AMPs)
APPLY
OUTPUT VOLTs
REF. DATA SHEET 22744
OUTPUT VOLTs 11.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs


7
14:29:02 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
1600RPM 1/4 LOAD (43 AMPs)
APPLY
OUTPUT VOLTs
REF. DATA SHEET 22744
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs



14:24:25 01 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN
1600RPM 1/4 LOAD (13AMPs)
REMOVE
8
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22744
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 52.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 2 SERIAL NO. GCU 103 / CURRENT 326; GEN 101 / SENSORS 123 COG. ENGR. Harmat / Dedlak

ROTOR NO. STATOR NO.

DATE OF TEST 6/6/88 TEST LETTER NO. QP387 TESTED BY R. J. SANIUK

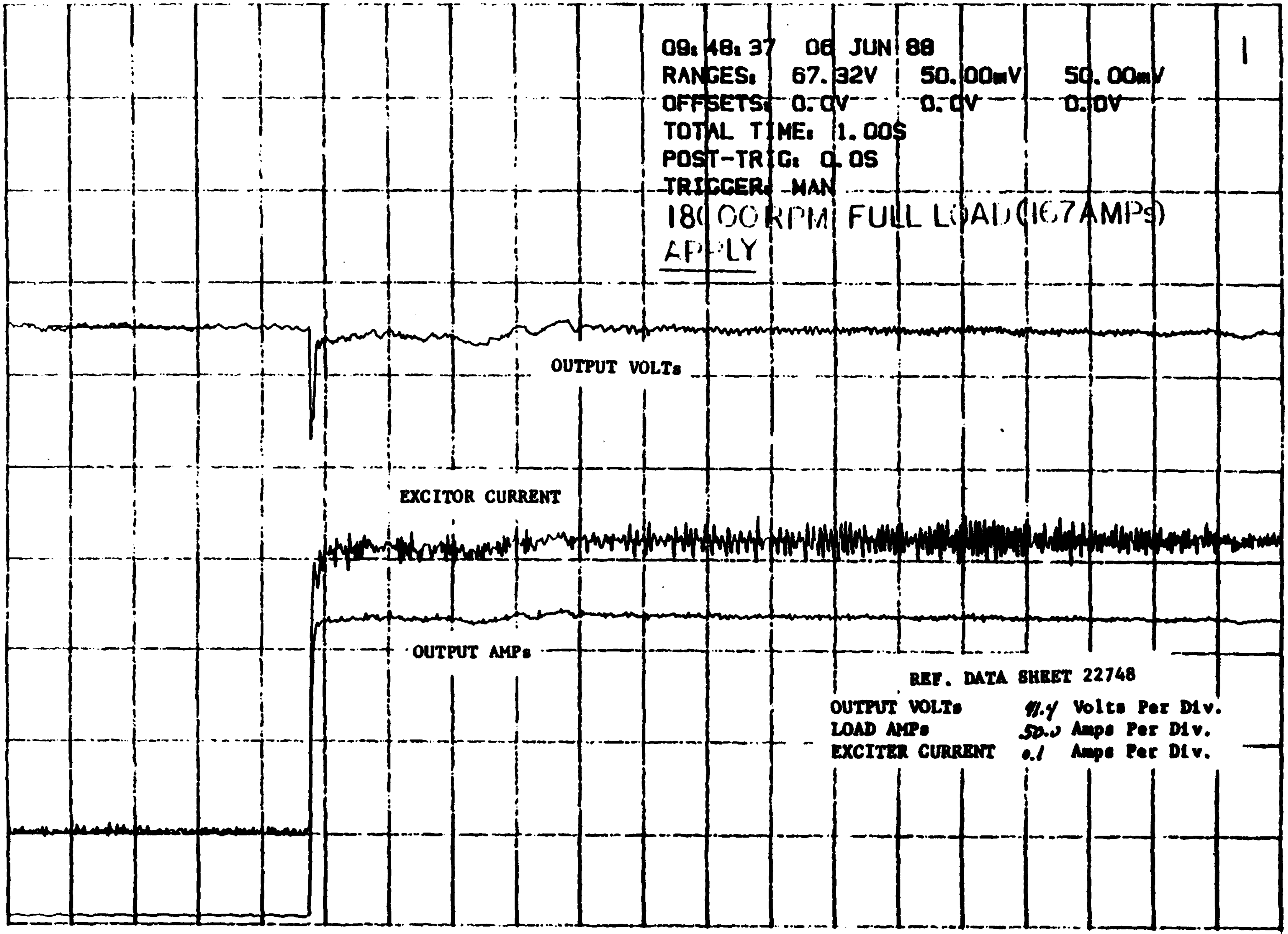
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

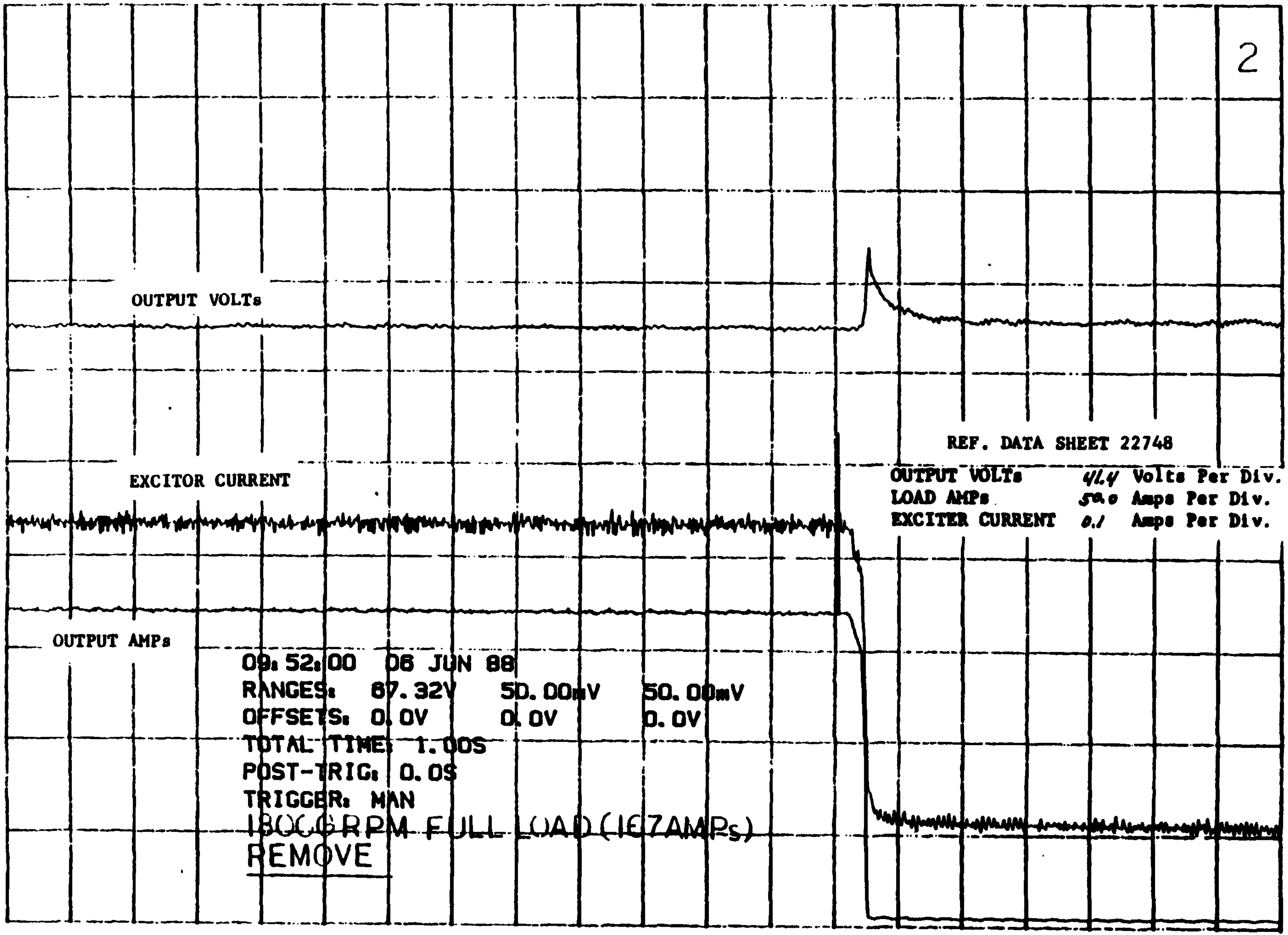
TITLE: VOLTAGE REGULATION STABLE 16K - TEST 18000 RPM

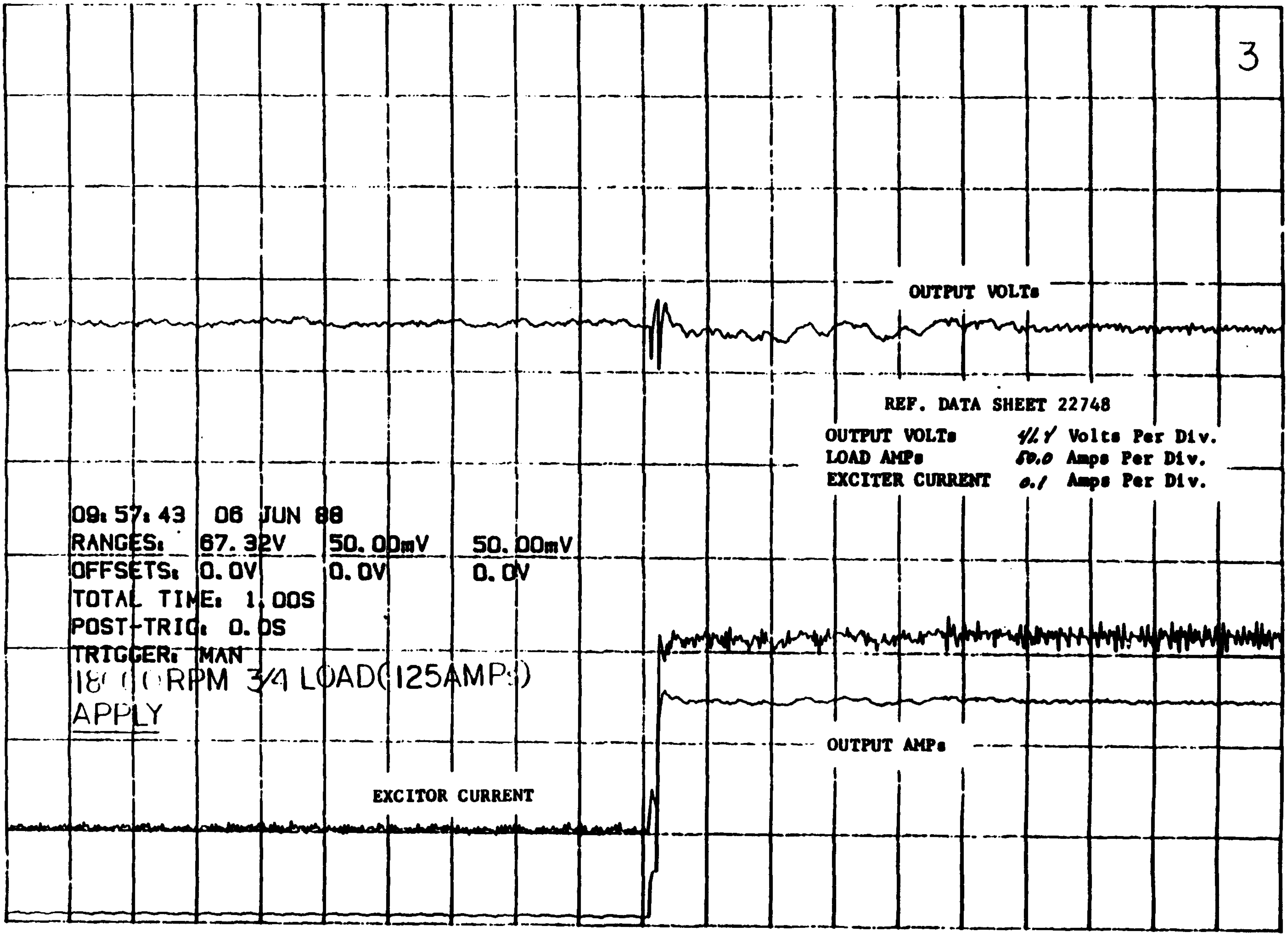
PARA. NO. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT POR	OUTPUT AMP LOAD	EXCITOR AMP.	OIL IN	OIL OUT	TEMP °F STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN		RIPPLE +	RIPPLE −	CHART NO
16000	0917	85.5	267.6	169	0.443	113.5	156.5	351.0	338.3	162.5	123.9	6.0	11.0	560	3.24		2.0	4.0	
16050	0924	86.9	267.3	169	0.45	120.9	165.2	387.8	382.7	162.0	143.3	7.0	11.0	590	3.42		2.5	4.0	
16050	0930	87.3	267.3	169	0.45	122.1	167.4	390.4	386.7	163.6	144.4	7.0	11.0	592	3.43		2.5	4.0	
16050	0935	87.8	267.3	169	0.45	122.1	167.5	389.5	386.9	163.2	145.0	7.0	11.0	595	3.44		2.5	4.0	
16050	0940	87.9	267.4	162	0.45	122.6	167.9	388.4	386.1	164.0	146.1	7.0	11.0	596	3.45		2.5	4.0	
18000	0942	87.3	268.1	170	0.421	124.4	170.9	379.9	382.7	165.9	146.5	7.0	11.0	620	3.59		4.0	4.0	
17000	0945	86.5	267.3	169	0.43	124.9	170.3	350.0	350.2	164.8	148.5	7.0	11.0	615	3.56		2.0	4.0	1
18150	0948	86.5	268.7	0	0.105	125.0	170.3	325.9	348.9	163.9	148.6	7.0	11.0	595	3.44		2.0	2.0	2
18000	0952	87.3	267.6	125	0.32	117.0	158.4	274.2	274.7	153.3	139.2	7.0	11.0	595	3.44		4.0	4.0	
18350	0954	86.7	268.3	125	0.325	115.9	156.3	258.3	260.1	151.5	138.9	7.0	11.0	589	3.41		4.0	4.0	3
18150	0957	87.5	268.9	0	0.11	115.4	154.8	250.3	260.7	149.6	137.3	7.0	10.5	572	3.31		2.0	2.0	4
18000	1001	87.0	266.9	84	0.235	109.7	147.0	214.0	213.8	142.0	131.7	6.5	10.0	565	3.27		4.0	4.0	
17550	1003	86.9	267.6	84	0.236	109.9	146.7	210.4	210.5	141.8	131.9	6.5	10.0	509	3.24		3.0	4.0	5
18000	1007	87.2	268.6	0	0.101	109.3	145.7	192.7	188.6	139.9	131.5	6.0	10.0	560	3.24		2.0	2.2	6
18100	1010	85.4	266.6	43	0.156	107.5	142.8	182.2	182.6	137.3	129.3	6.0	10.0	561	3.25		2.0	2.5	
17800	1012	85.4	266.4	43	0.157	107.1	142.1	179.6	180.5	136.4	129.0	6.0	10.0	555	3.21		2.0	2.5	7
18000	1016	85.2	269.1	0	0.11	106.1	140.6	175.9	177.3	135.0	127.3	6.0	10.0	550	3.18		2.0	2.1	8
														~~545~~					
1605	1019	86.2	268.7	169	0.44	105.2	140.8	256.3	232.0	137.6	124.9	6.0	10.0	545	3.16		2.0	4.0	

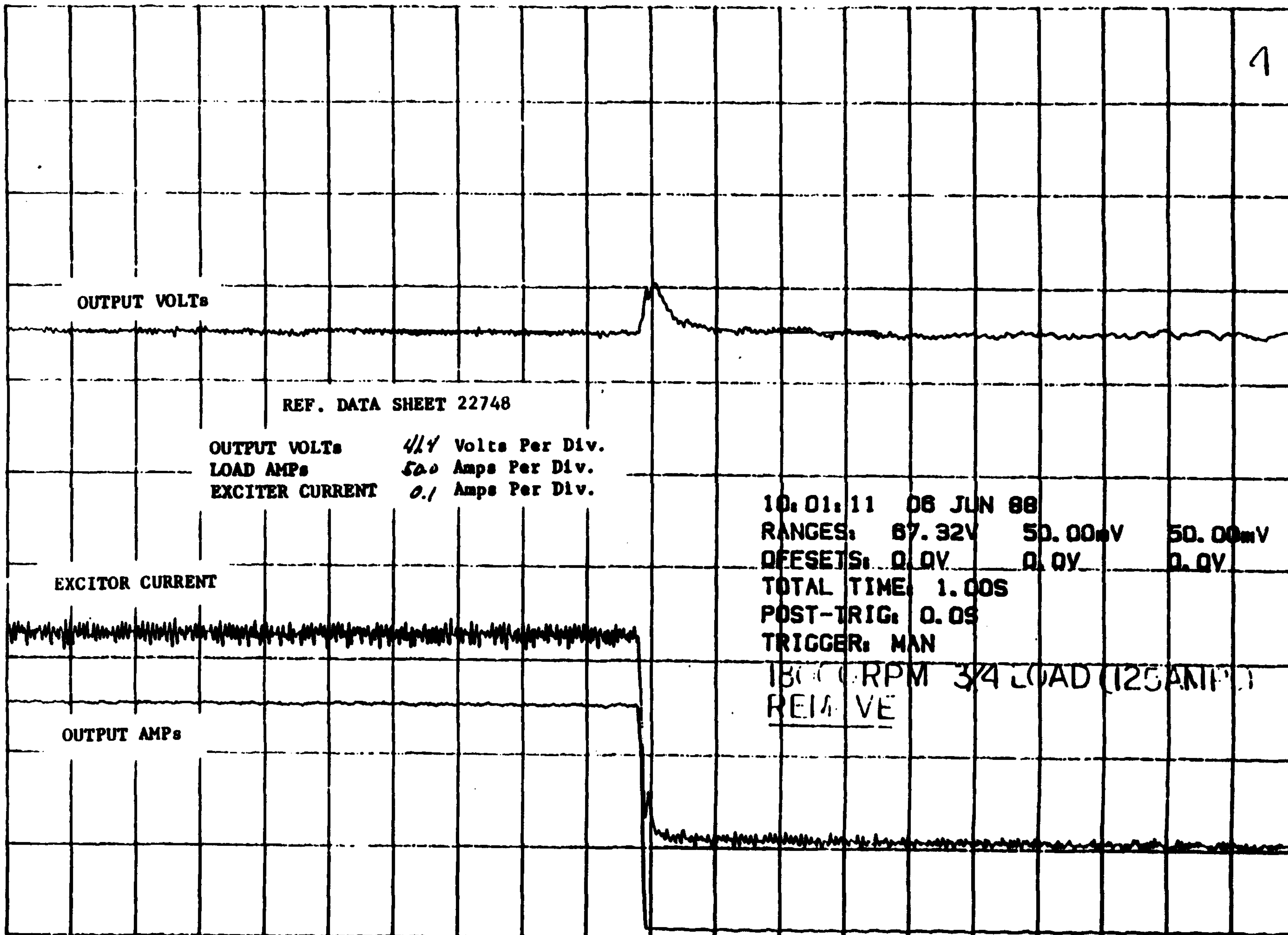
COX FLOW METER 12K K FACTOR 172[illegible]

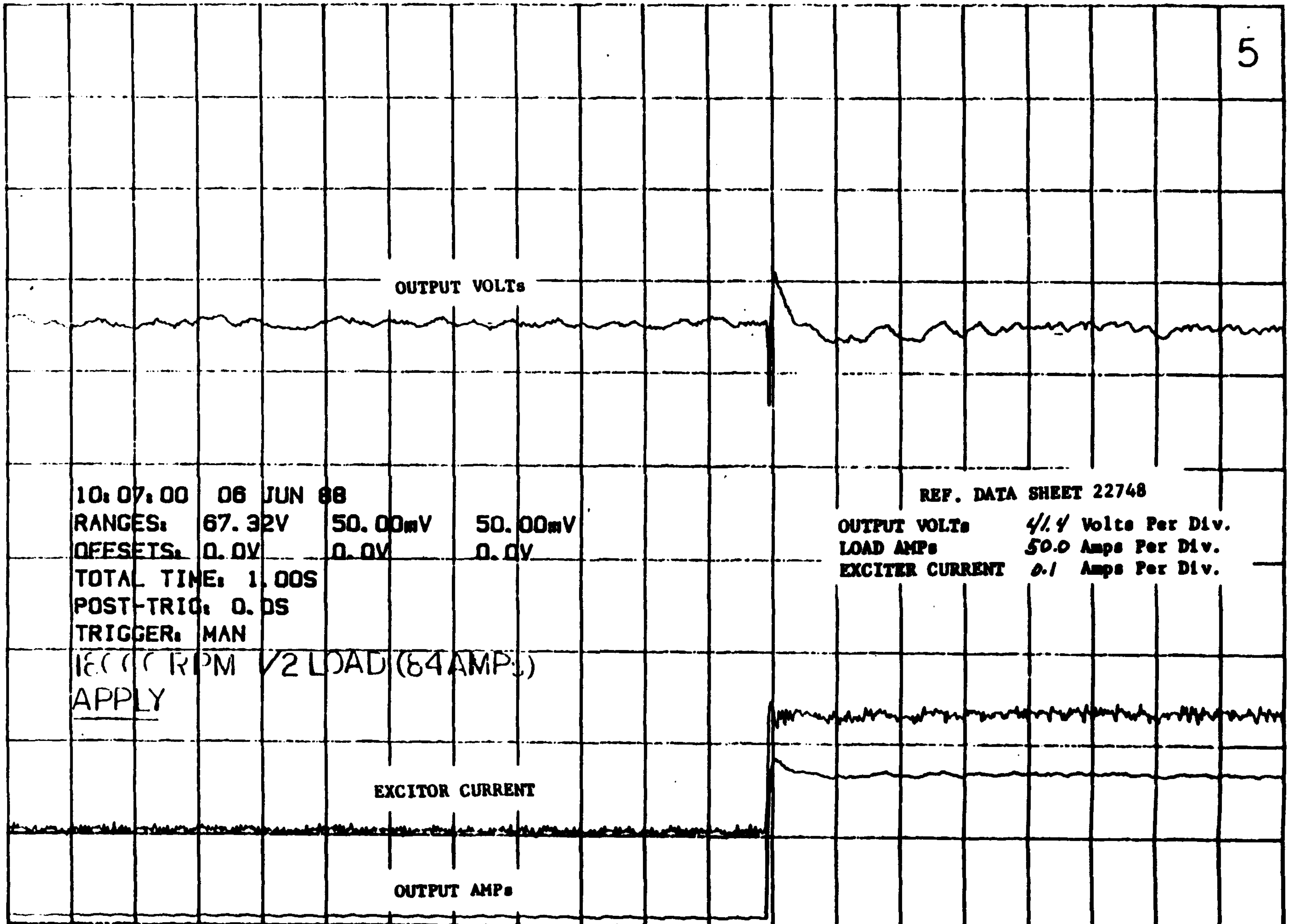
PRECEEDING FOLLOWING

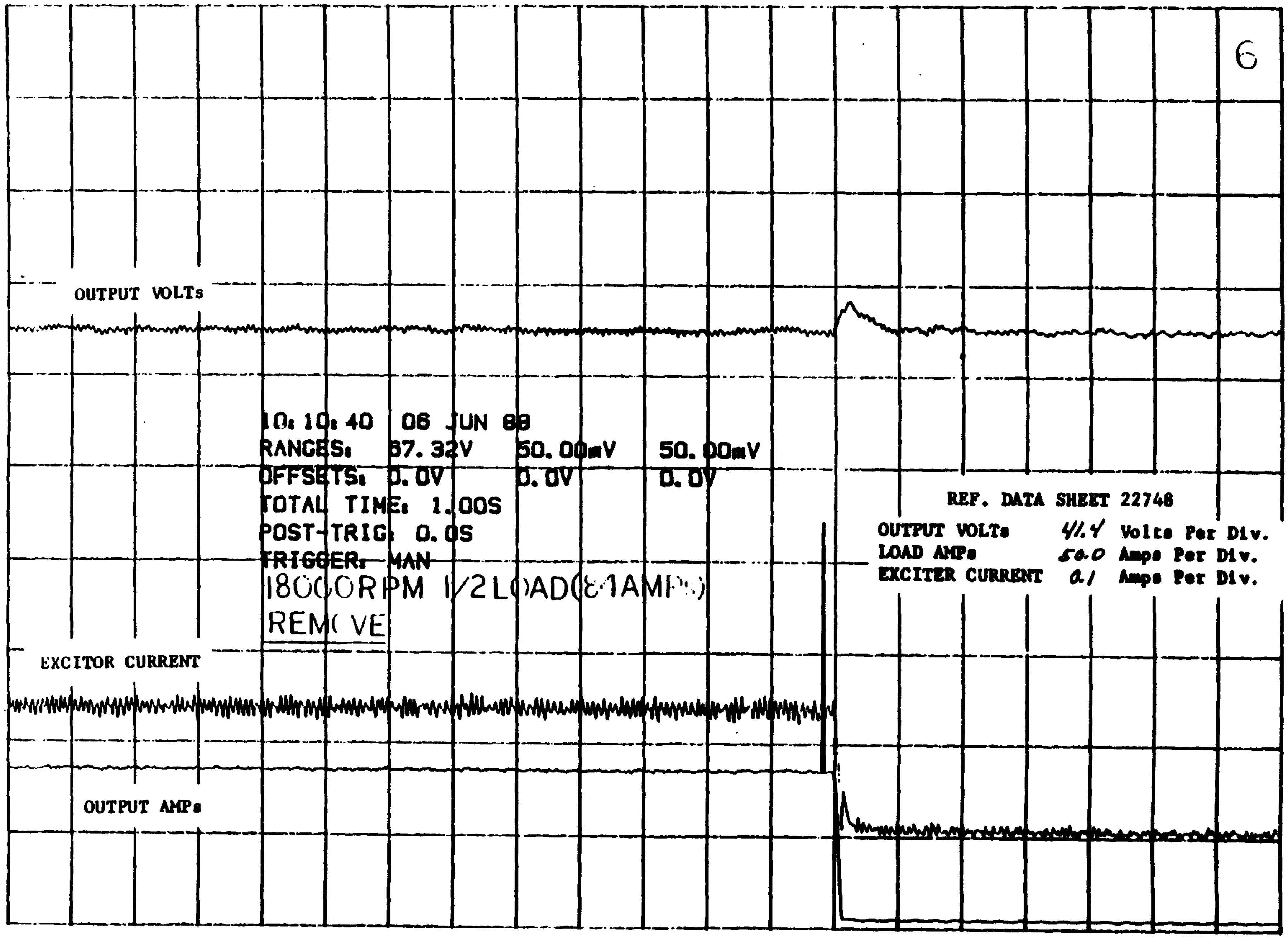

1
09:48:37 06 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
1800RPM FULL LOAD (167AMPs)
APPLY
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22748
OUTPUT VOLTs 11.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

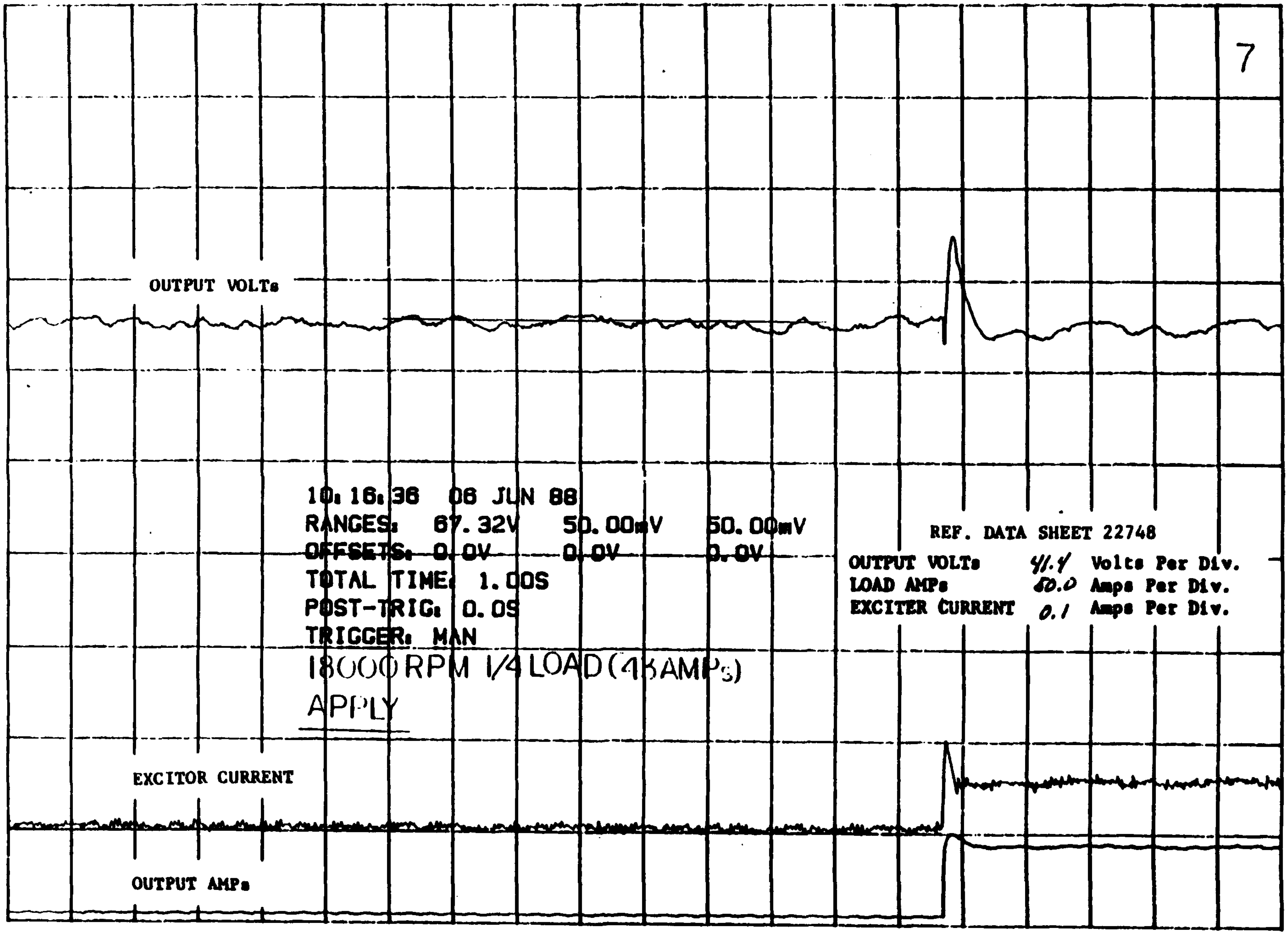

2
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
REF. DATA SHEET 22748
OUTPUT VOLTs 44 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
09:52:00 06 JUN 88
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
1800RPM FULL LOAD (167AMPs)
REMOVE

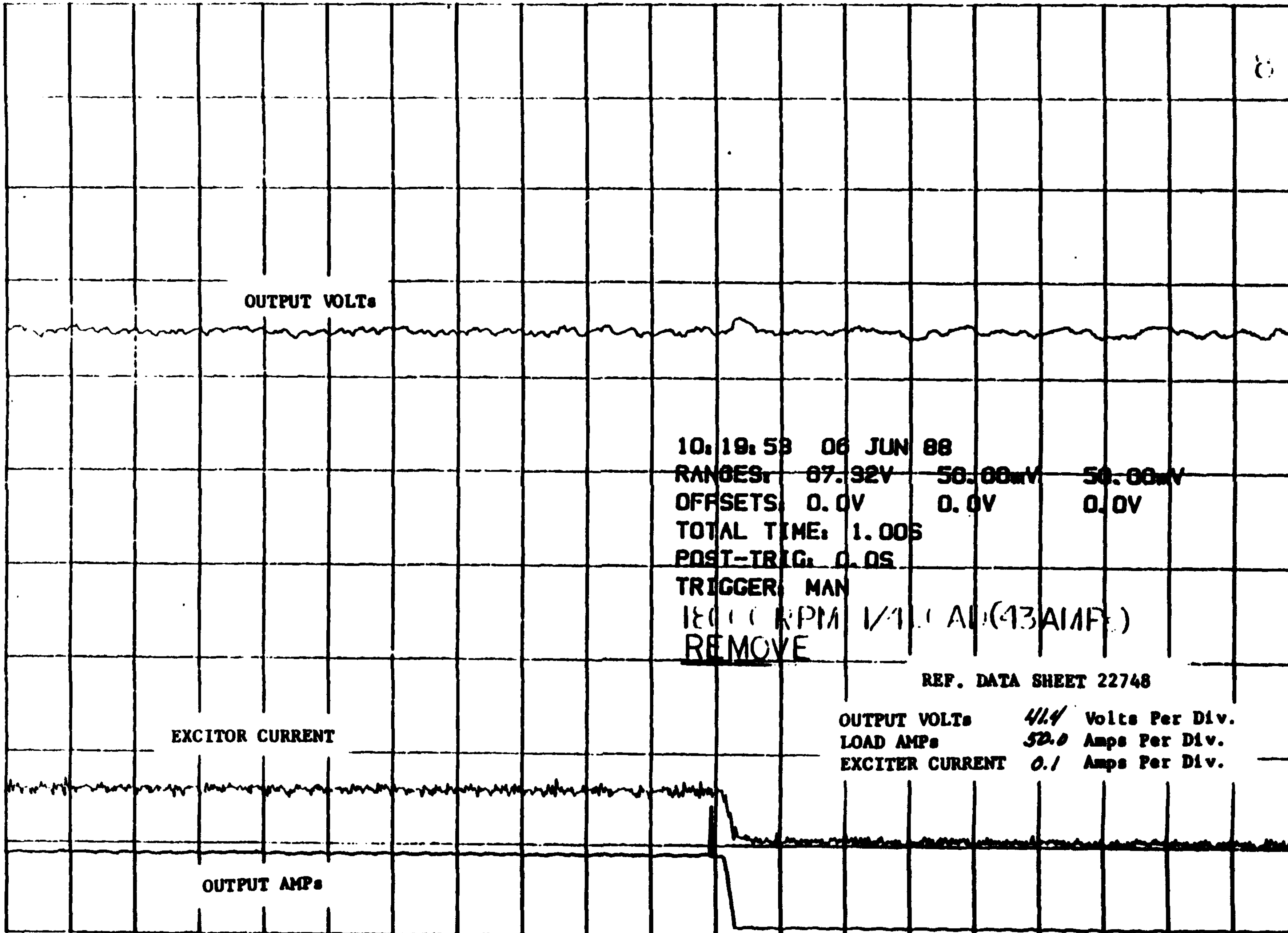

3
OUTPUT VOLTs
REF. DATA SHEET 22748
OUTPUT VOLTs Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
09:57:43 06 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
RPM 3/4 LOAD(125AMPS)
APPLY
OUTPUT AMPs
EXCITOR CURRENT


OUTPUT VOLTs
REF. DATA SHEET 22748
OUTPUT VOLTs 4.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
10:01:11 06 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
RPM 3/4 LOAD
EXCITOR CURRENT
OUTPUT AMPs


5
OUTPUT VOLTs
10:07:00 06 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
1800 RPM 1/2 LOAD (64 AMPS)
APPLY
REF. DATA SHEET 22748
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs


6
OUTPUT VOLTs
10:10:40 06 JUN 88
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
REF. DATA SHEET 22748
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs


7
OUTPUT VOLTs
10:16:36 06 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
18000 RPM 1/4 LOAD (43 AMPs)
APPLY
REF. DATA SHEET 22748
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs


OUTPUT VOLTs
10:19:58 06 JUN 88
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
REMOVE
REF. DATA SHEET 22748
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs

5.5 <u>Short Circuit Capacity</u>

Purpose: The purpose of this test was to verify the system's ability to deliver 150 percent of rated current (250 amperes) for seven seconds.

Procedure: The generator was operated at rated load (167 amperes) and 16,000 rpm until stabilized. At that time a 200 ampere additional load was applied for seven seconds. It was necessary to disable the undervoltage circuit of the GCU so that the system would operate for the full seven seconds.

Results: Test results are recorded on data sheet 21286 and chart 21286-A

Discussion of Results: The current limit of the GCU limited the generator current to 250 amperes. Winding temperatures changed unperceptibly. The requirement was met.

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 2 SERIAL NO. GCU 103 / CURRENT 326; GEN 101 / SENSORS 123 COG. ENGR. HARMAT / DEN IK ROTOR NO. STATOR NO.

DATE OF TEST 6/10/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: SHORT CIRCUIT CAPACITY PAGE OF

RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R	OUTPUT AMP LOAD	EXCITOR AMP	EXCITOR VOLT	OIL IN	OIL OUT	STATOR #1	STATOR #2	GEN CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	OIL GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.	
																				69
16000	1032	75.1	267.3	169	0.445	88.0	120.4	163.7	375.2	364.6	160.8	133.7	7.0	11.0	596	3.42	2.0	4.0		
16000	1035	76.5	266.9	169	0.449	90.0	122.3	166.7	392.9	385.2	157.4	127.3	7.0	11.0	590	3.42	2.0	3.8		5.8
16000	1040	76.6	267.1	169	0.45	91.5	123.6	167.9	401.1	394.4	158.1	127.8	7.0	11.0	594	3.44	2.2	4.0		5.8
16000	1045	77.3	267.1	169	0.45	91.3	123.4	168.3	403.2	396.6	158.8	128.9	7.0	11.0	595	3.44	2.2	4.0		5.8
16000	1050	78.2	267.2	169	0.45	92.0	123.4	168.6	404.0	397.5	158.9	128.9	7.0	11.0	595	3.44	2.2	4.0		5.8
16000	1055	78.5	267.2	169	0.45	92.0	123.7	168.7	404.3	397.7	159.2	129.1	7.0	11.0	595	3.44	2.2	4.0		5.8
				— STABILIZED —																
16000	1101	78.3	173.	250	0.66	127.0	124.0	168.9	404.9	398.5	159.7	128.3	7.0	11.0	580		—	—		

SHORT CIRCUIT – 7 SECONDS LOAD.

1

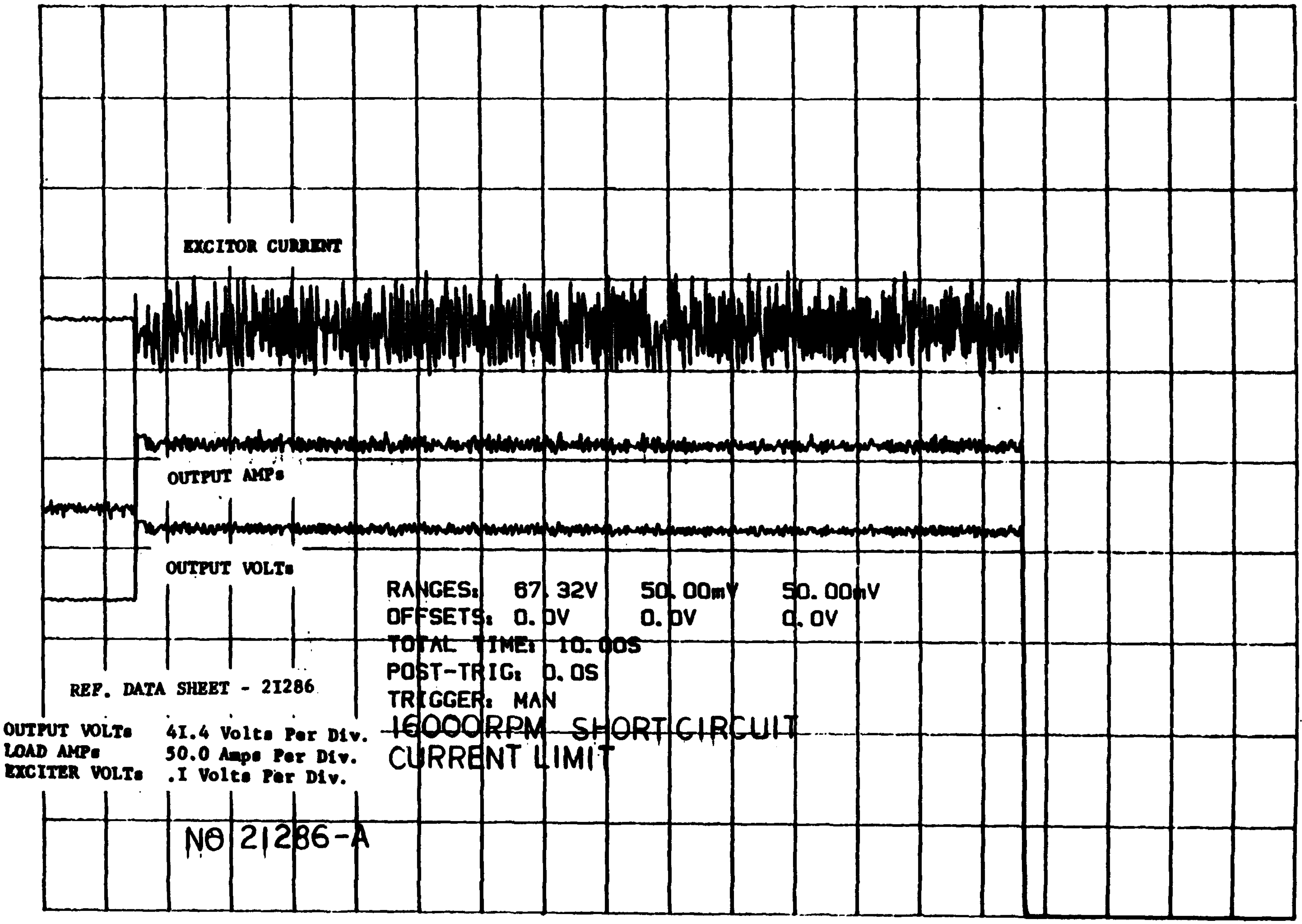
SEE CHART MARKED 21286-A

NOTE: DUE TO MULTIPLE SAFTY CIRCUITS, WHICH CUT THE SYSTEM OFF QUICKER (APPROXAMENTLY 5 SECONDS) CR304 WAS SHORTED TO GROUND TO DISABLE THESE CIRCUITS, SO THE 7 SECOND TIME DELAY TRIP CAN BE SHOWN.

FORM 1349 R/S (12/63) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG.

NO: 21286

07225


EXCITOR CURRENT
OUTPUT AMPs
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: MAN
16000RPM SHORT CIRCUIT
CURRENT LIMIT
REF. DATA SHEET - 21286
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER VOLTs .1 Volts Per Div.
NO 21286-A

5.6 **Paralleling**

Purpose: the purpose of this test was to demonstrate that two systems operated in parallel meet specified voltage and load-sharing requirements.

Procedure: Two systems, connected in parallel, were operated at 16,000 rpm with rated load on each system. Operation was continued until both systems reached temperature stabilization.

Following stabilization, the following tests were run:

Test	System	Speed	Bus Loads
1	I	16,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	
2	I	9,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	
3	I	18,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	

Results: Test 1 results were recorded on: data sheets 19941-A and charts 19941-A 1 through 6 for system I; data sheets 19941-B and charts 19941-B1 through 6 for system II. Test 2 results were recorded on: data sheets 19941-C and charts 19941-C1 through 6 for system I; data sheets 19941-D and charts 19941-D1 through 6 for system II.

Test 3 results were recorded as: data sheets 19941-E and charts 19941-E1 through 6 for system I; data sheets 19941-F and charts 19941-F1 through 6 for system II. A summary of the transient data is shown as Table 5-3.

Discussion of Results: The summary of test data shown in Table 5-3 indicates, that the two parallel generator systems met the specification requirements. Some anomalies shown mostly at the low speed (9,000 rpm) operation, where high modulation was experienced (see traces) can be explained by the generator drive stand "hunting" effect. The modulation frequency varied from 80-150 Hz. which could have been caused by the gear-box or drive-shaft resonant frequencies.

TABLE 5-3

Paralleling: Transient Performance

Test	Bus Load	RPM	Max. Volts	Recovery MS.	Min. Volts	Recovery MS.	RPM	Max. Volts	Recovery MS.	Min. Volts	Recovery MS.
1	1/3	16,000	273	10	258	12	9,000	272	3	258	12
	2/3		283	12	238	6		285	8	236	6
	Full		280	24	215	12		281	18	250	12
2	1/3	9,000	INDETERMINATE				9,000	INDETERMINATE			
	2/3		280	10	245	7		286	26	INDETERMINATE	
	Full		280	20	238	10		280	10	226	33
3	1/3	18,000	WITHIN REGULATION LIMITS*				9,000	WITHIN REGULATION LIMITS*			
	2/3		280	32	246	12		275	10	249	8
	Full		281	20	242	20		281	18	238	20

* Steady State Limits

LUCAS AEROSPACE
POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM I SERIAL NO. GCU 104 / GEN 164 CURRENT SENSORS 121 / 126 COG. ENGR. HARMAT/[illegible] ROTOR NO. STATOR NO.

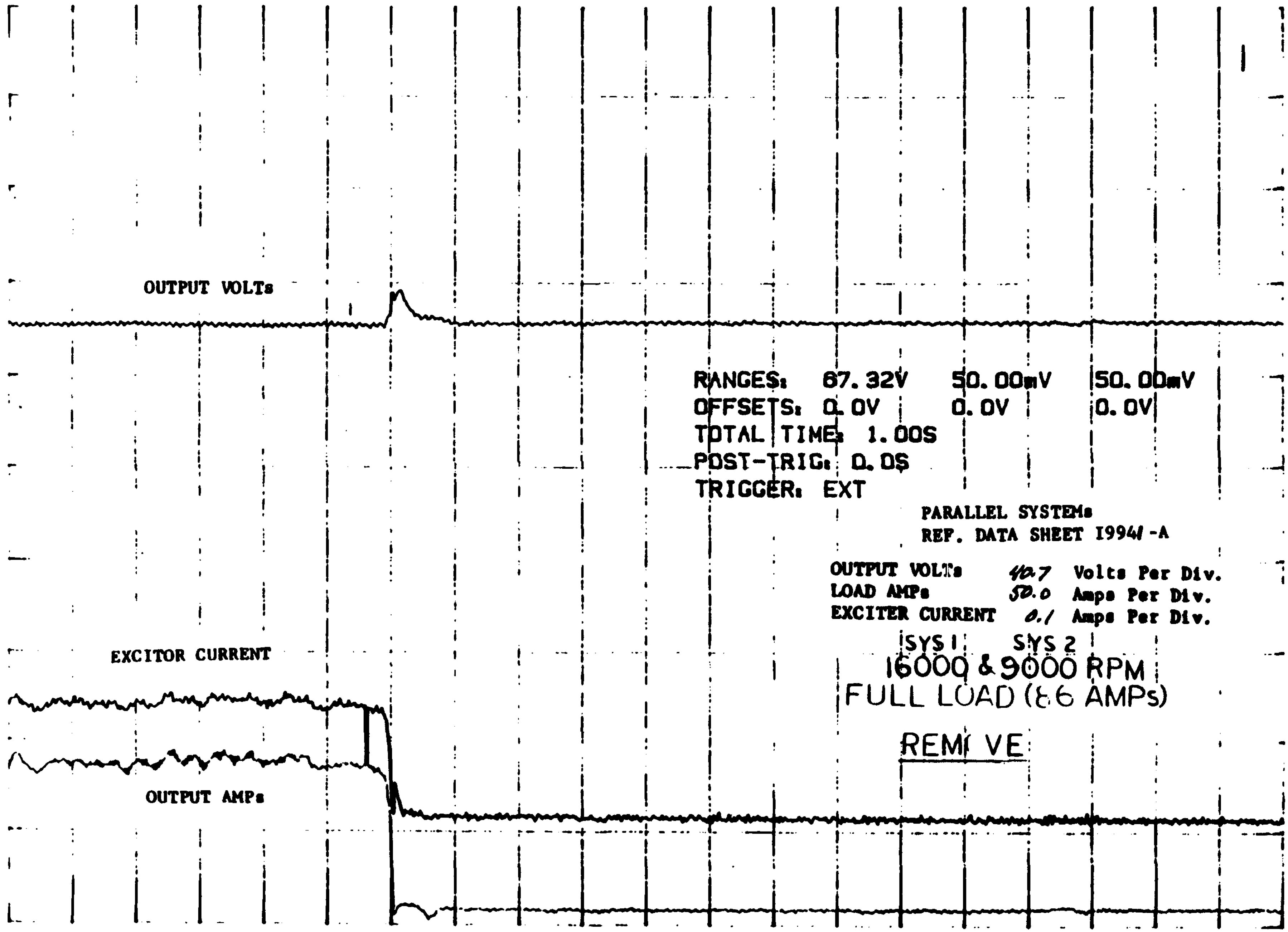
DATE OF TEST 7/14/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

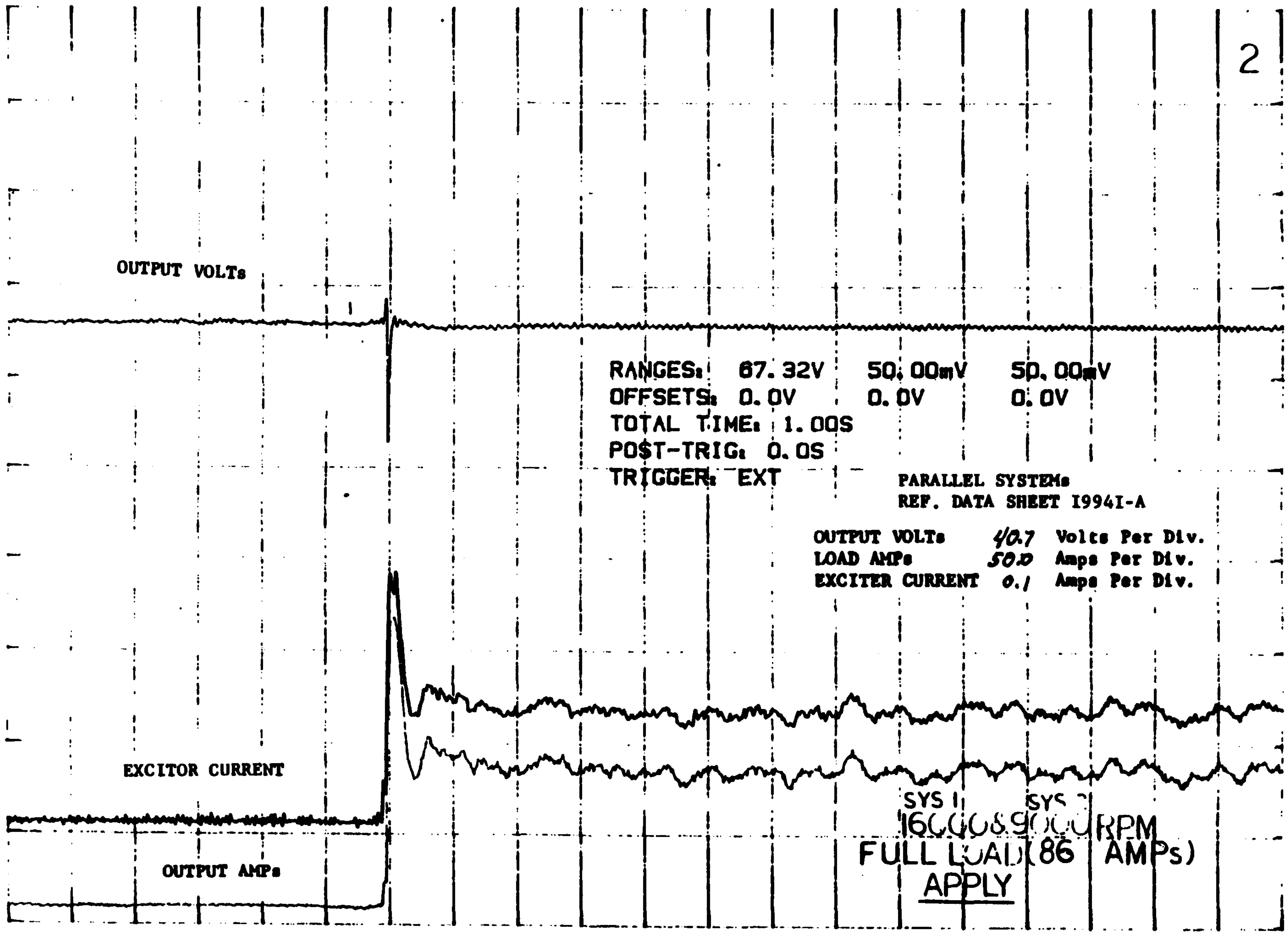
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

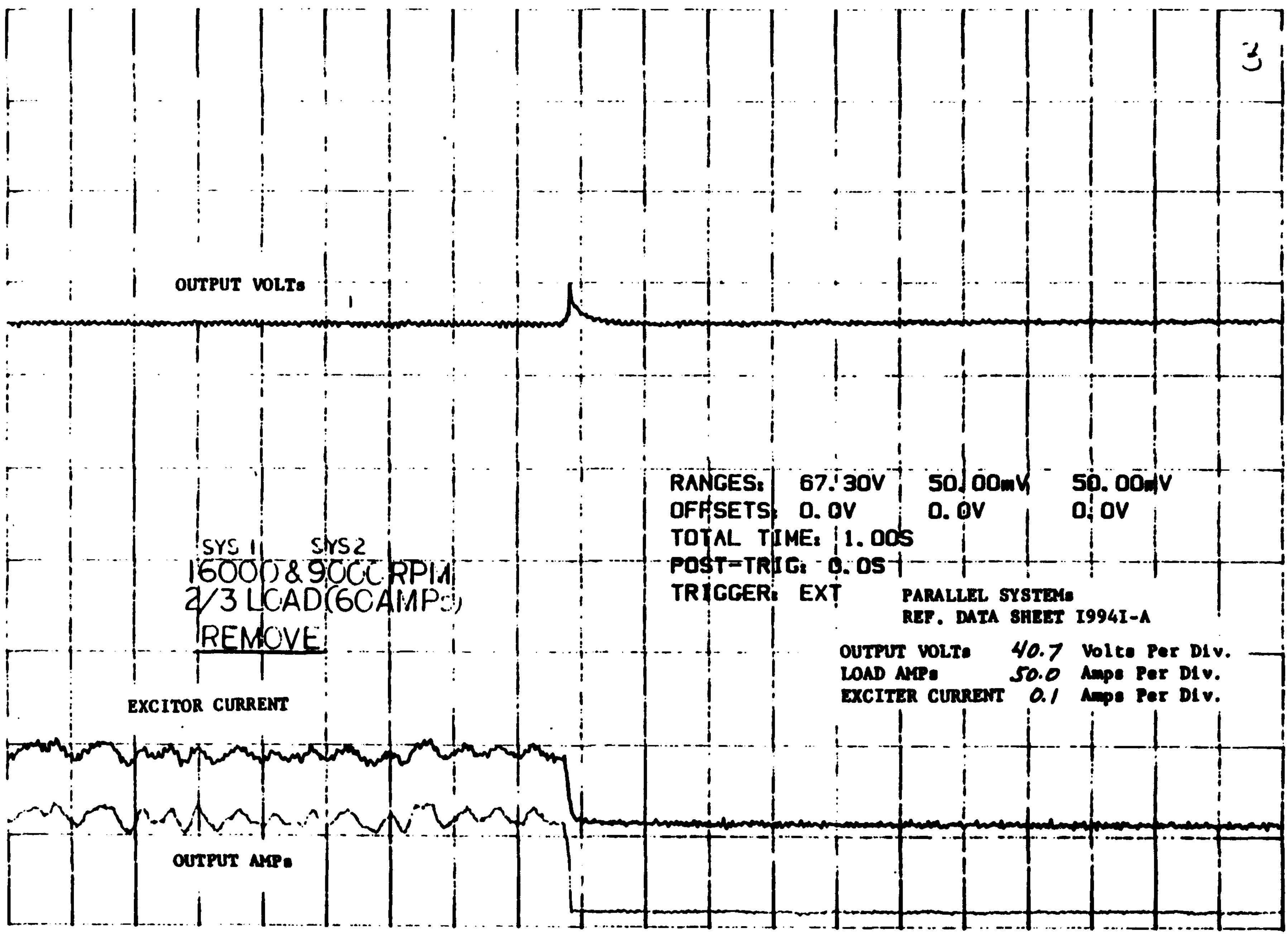
TITLE: 49.3 "B" PARALLEL SYSTEMS 9000 & 16000 RPM. PAGE OF

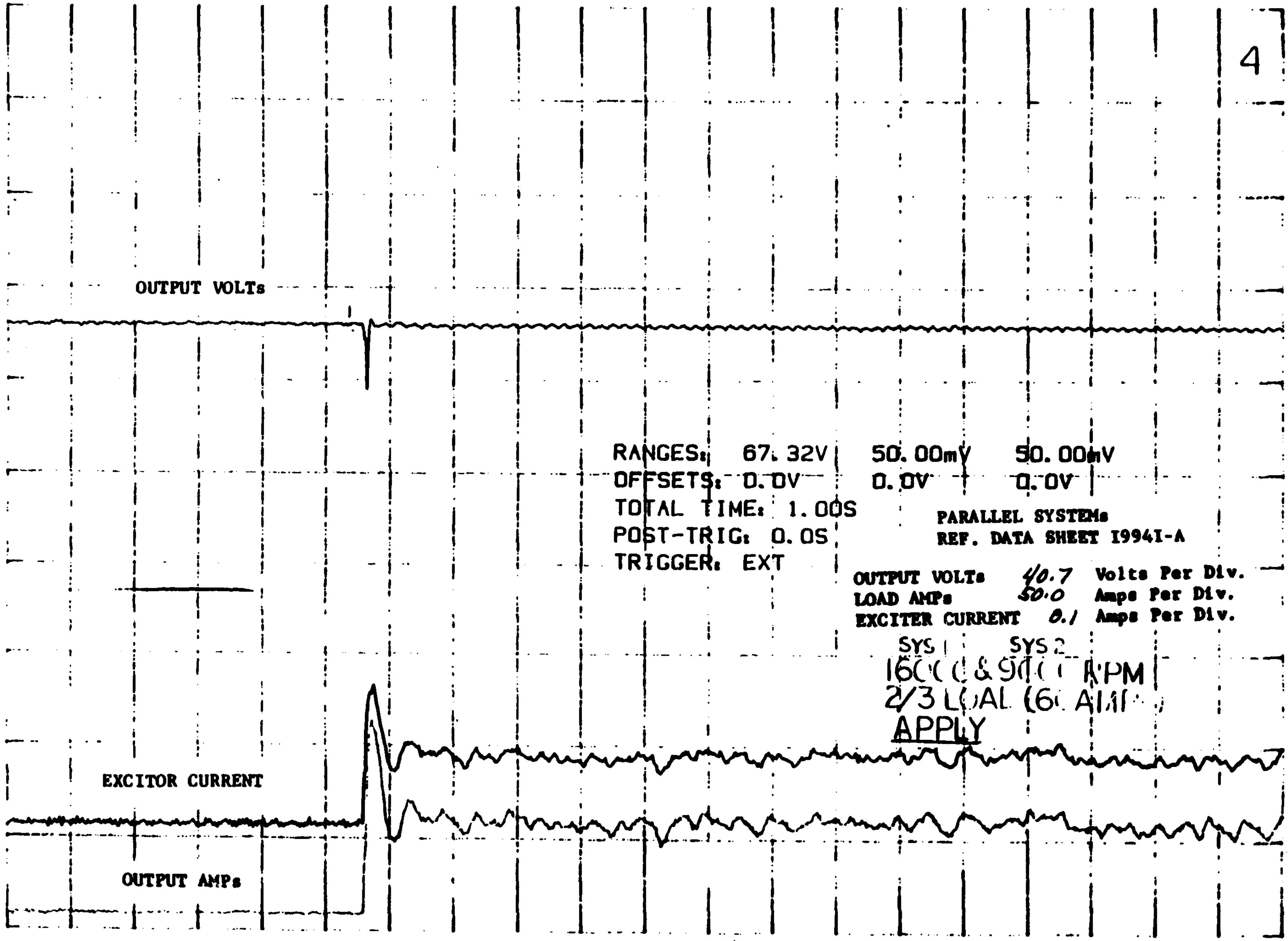
G5

RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
6050	1345	97.9	266.3	85	0.23	41.0	94.5	121.8	186.6	191.4	117.7	114.7	8.0	14.5	555	3.36	2.0	3.0	
6000	1400	99.4	266.2	85	0.235	42.0	99.8	131.7	214.8	219.9	130.8	124.6	8.0	14.0	555	3.36	2.0	2.5	
6050	1405	99.1	266.3	85	0.233	42.0	100.0	132.0	215.5	220.9	130.8	124.6	8.0	14.0	555	3.36	2.0	2.5	
6000	1410	100.4	266.4	85	0.234	42.0	100.2	132.4	216.0	221.5	131.7	125.0	8.0	14.0	555	3.36	2.0	2.5	
6000	1415	100.0	266.4	85	0.235	42.0	100.5	132.4	216.4	222.2	132.2	125.6	8.0	14.0	555	3.36	2.0	2.5	
6050	1418	99.4	265.7	86	0.24	43.5	100.6	132.5	218.4	224.5	131.7	125.2	8.0	14.0	555	3.36	2.2	2.5	
5700	1421	100.0	267.6	54	0.11	40.0	100.6	131.9	141.8	155.0	130.7	126.3	8.0	14.0	555	3.36	2.0	2.0	1
6000	1425	99.5	265.8	87	0.24	42.5	99.5	130.5	206.3	212.5	129.2	124.0	8.0	14.0	555	3.36	2.2	2.5	2
5950	1431	100.0	265.5	60	0.19	34.0	100.1	131.0	197.3	202.3	129.8	124.9	8.0	14.0	556	3.36	2.0	2.5	
6200	1434	99.7	267.5	54	0.115	20.0	99.6	129.8	189.6	193.4	127.5	124.2	8.0	14.0	550	3.33	2.0	1.5	3
5950	1439	99.0	265.6	60	0.19	33.5	98.3	127.2	180.8	185.7	125.6	122.4	8.0	14.0	550	3.33	2.0	2.0	4
6050	1444	98.8	266.3	30	0.14	24.0	98.4	127.2	174.9	178.9	124.9	121.8	8.0	14.0	550	3.33	2.2	2.2	
6250	1448	98.4	267.3	54	0.12	2.0	98.2	126.6	170.2	174.0	123.9	121.7	8.5	14.5	556	3.36	2.0	2.0	5
6100	1453	97.9	265.9	30	0.14	24.0	97.6	125.8	167.4	171.3	122.8	120.5	8.5	14.0	555	3.36	2.0	2.2	6
6050	1458	99.7	266.6	85	0.24	42.0	98.2	128.2	199.5	206.0	126.6	122.0	8.5	14.3	555	3.36	2.2	2.5	


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
16000 & 9000 RPM
FULL LOAD (86 AMPs)
REMOVE


2
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
SYS 1 SYS 2
FULL LOAD (86 AMPs)
APPLY


3
OUTPUT VOLTs
SYS 1 SYS 2
16000 & 9000 RPM
2/3 LOAD (60AMPs)
REMOVE
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.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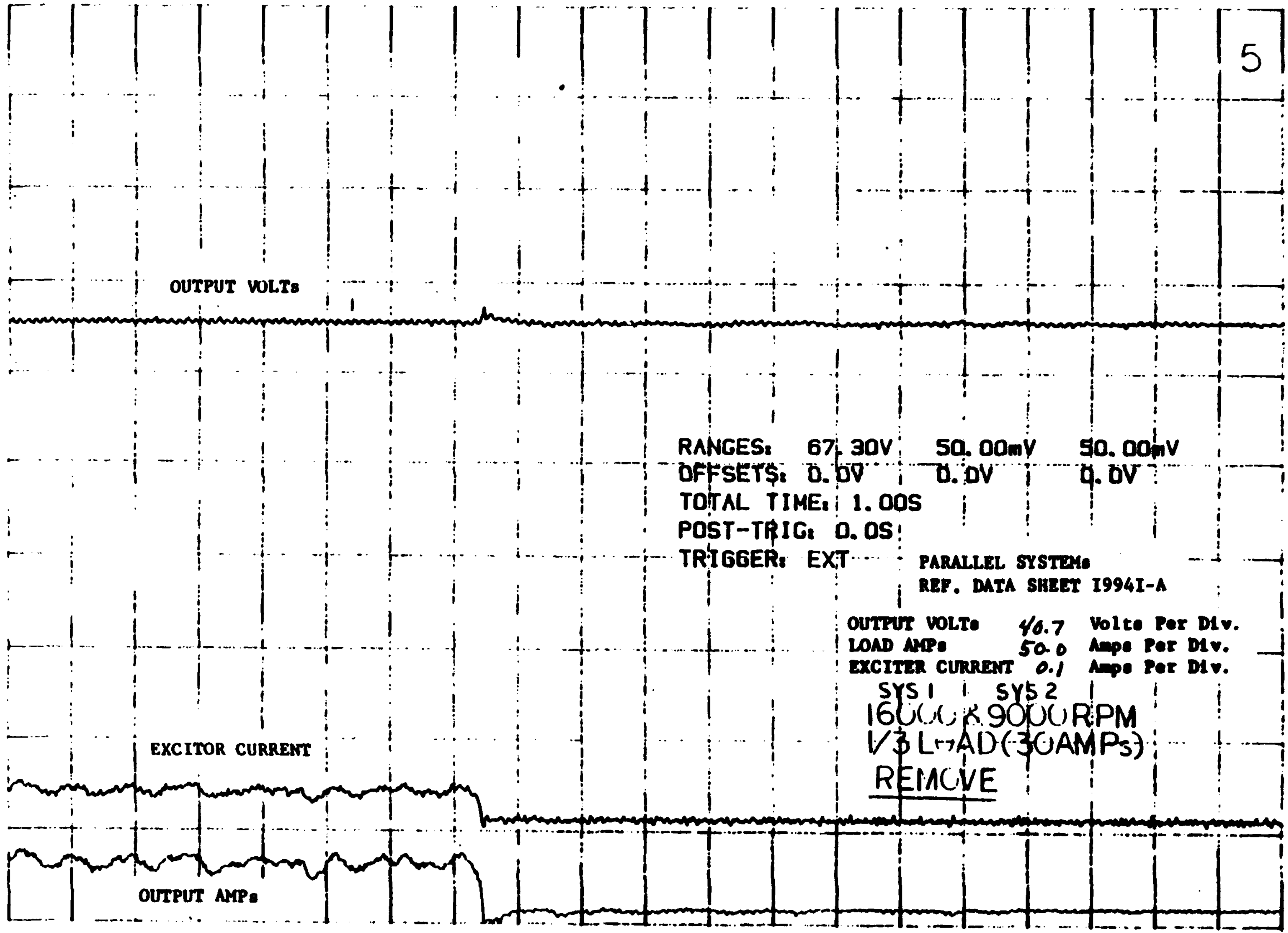
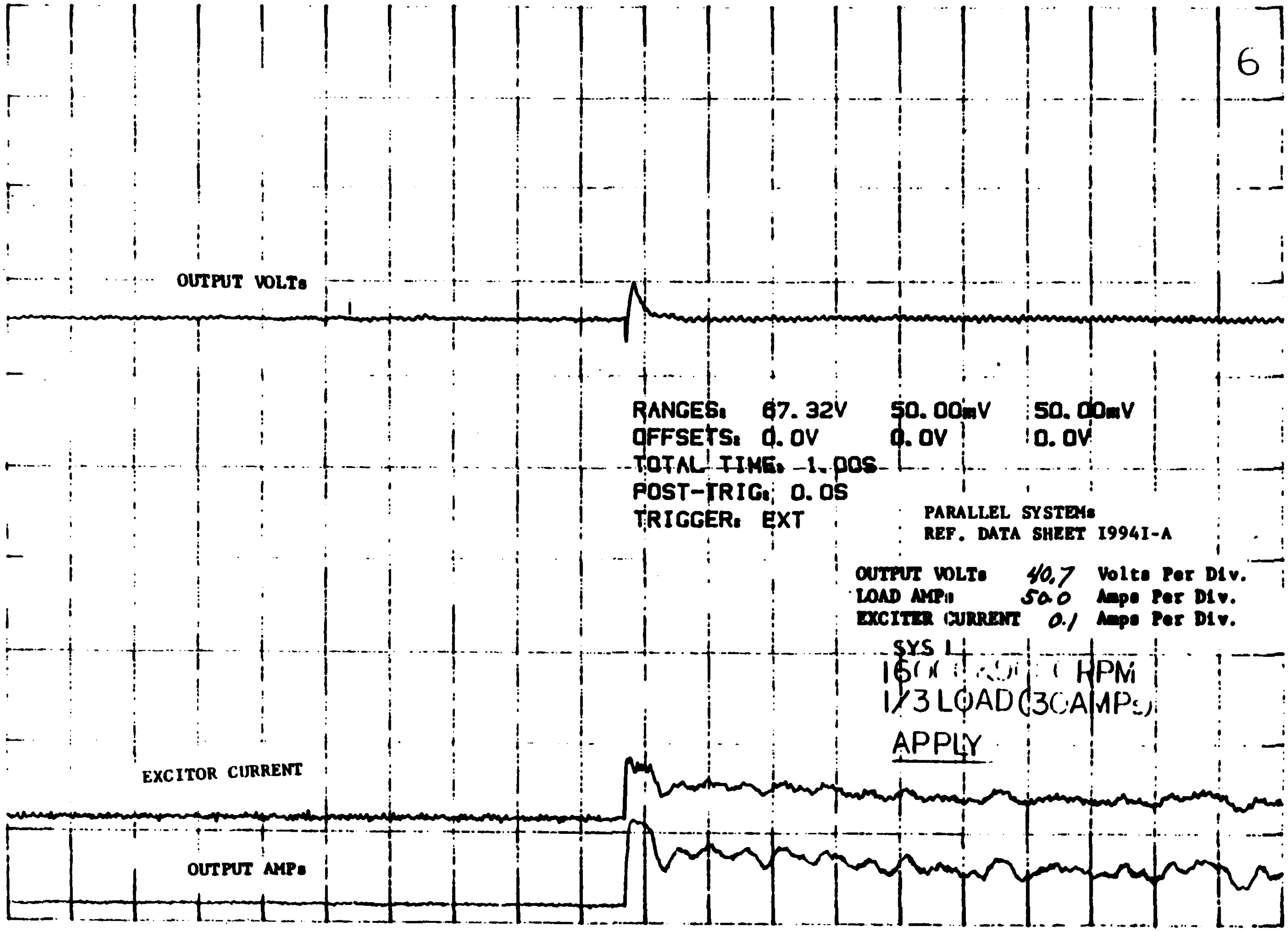
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
APPLY
EXCITOR CURRENT
OUTPUT AMPs


5
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
16000 & 9000 RPM
1/3 LOAD (30 AMPs)
REMOVE
EXCITOR CURRENT
OUTPUT AMPs


6
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-A
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS I
RPM
1/3 LOAD (30 AMPs)
APPLY
EXCITOR CURRENT
OUTPUT AMPs

LUCAS AEROSPACE
POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

W.O. 54805 MODEL NO. SYSTEM II SERIAL NO. GCU 103 / CURRENT 123, GEN 101 / SENSORS 321 COG. ENGR. HARMAT/Saniuk

ROTOR NO. STATOR NO.

DATE OF TEST 7/14/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.9.3 "B" PARALLEL SYSTEMS

PAGE OF

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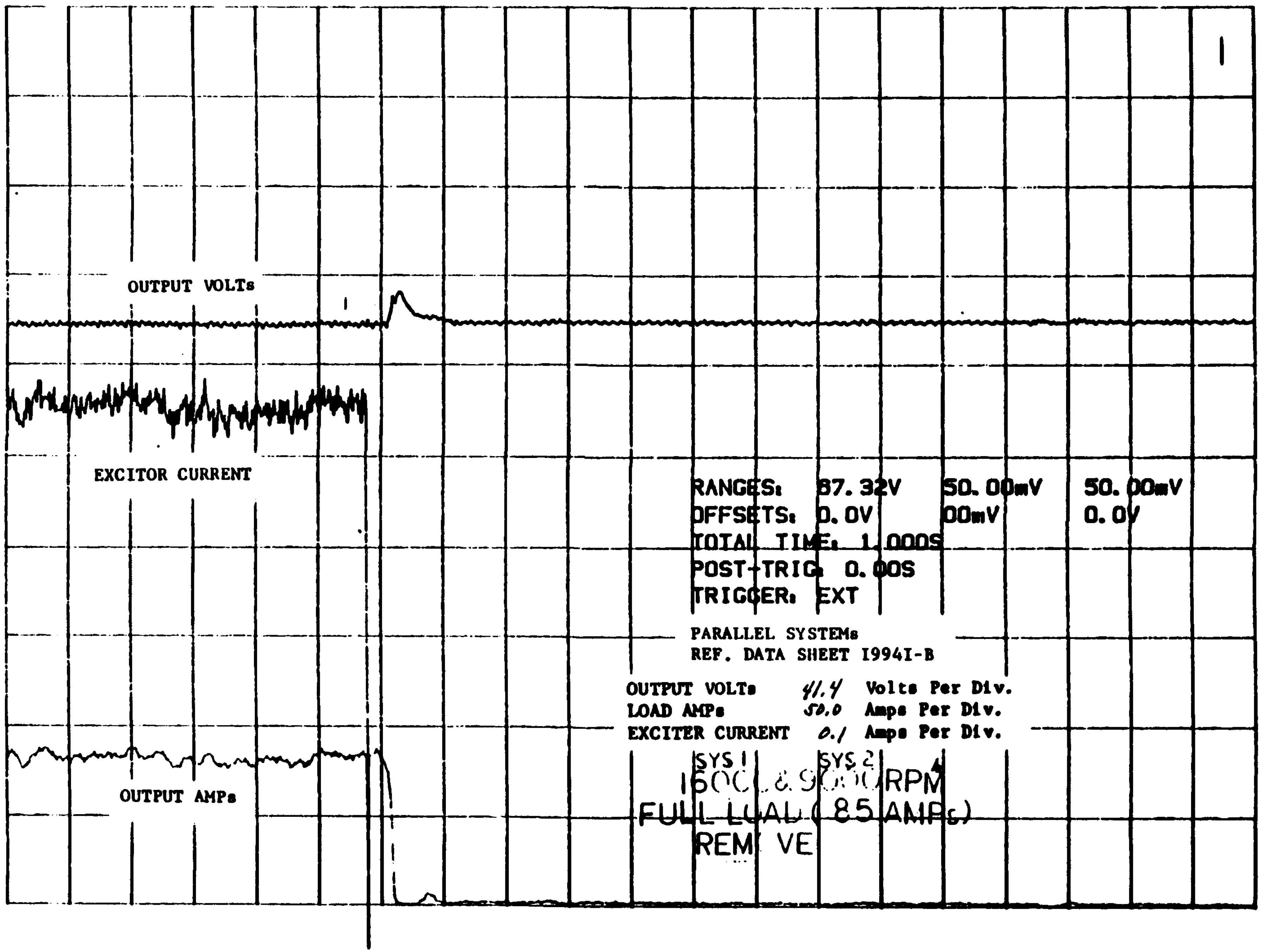
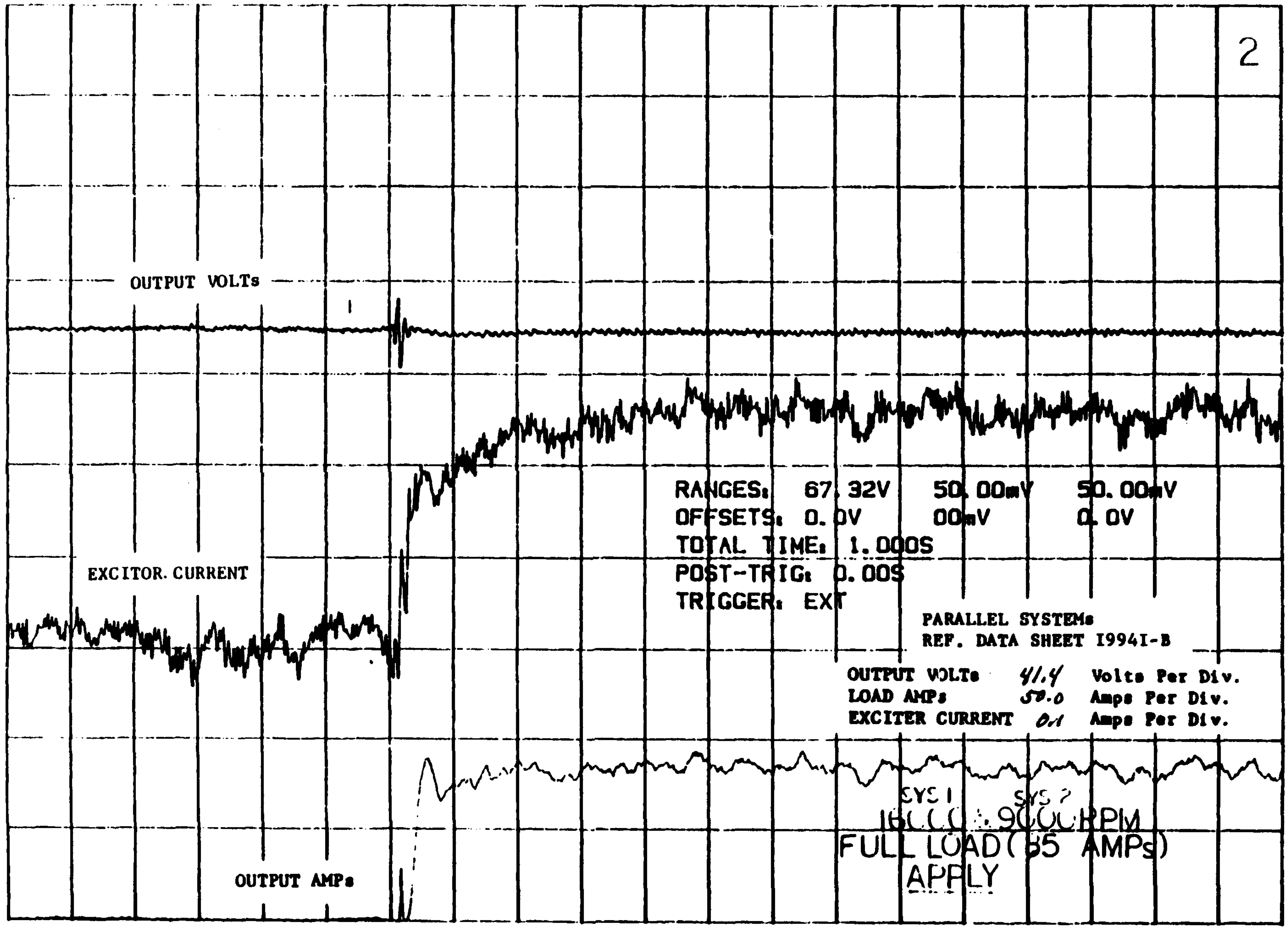
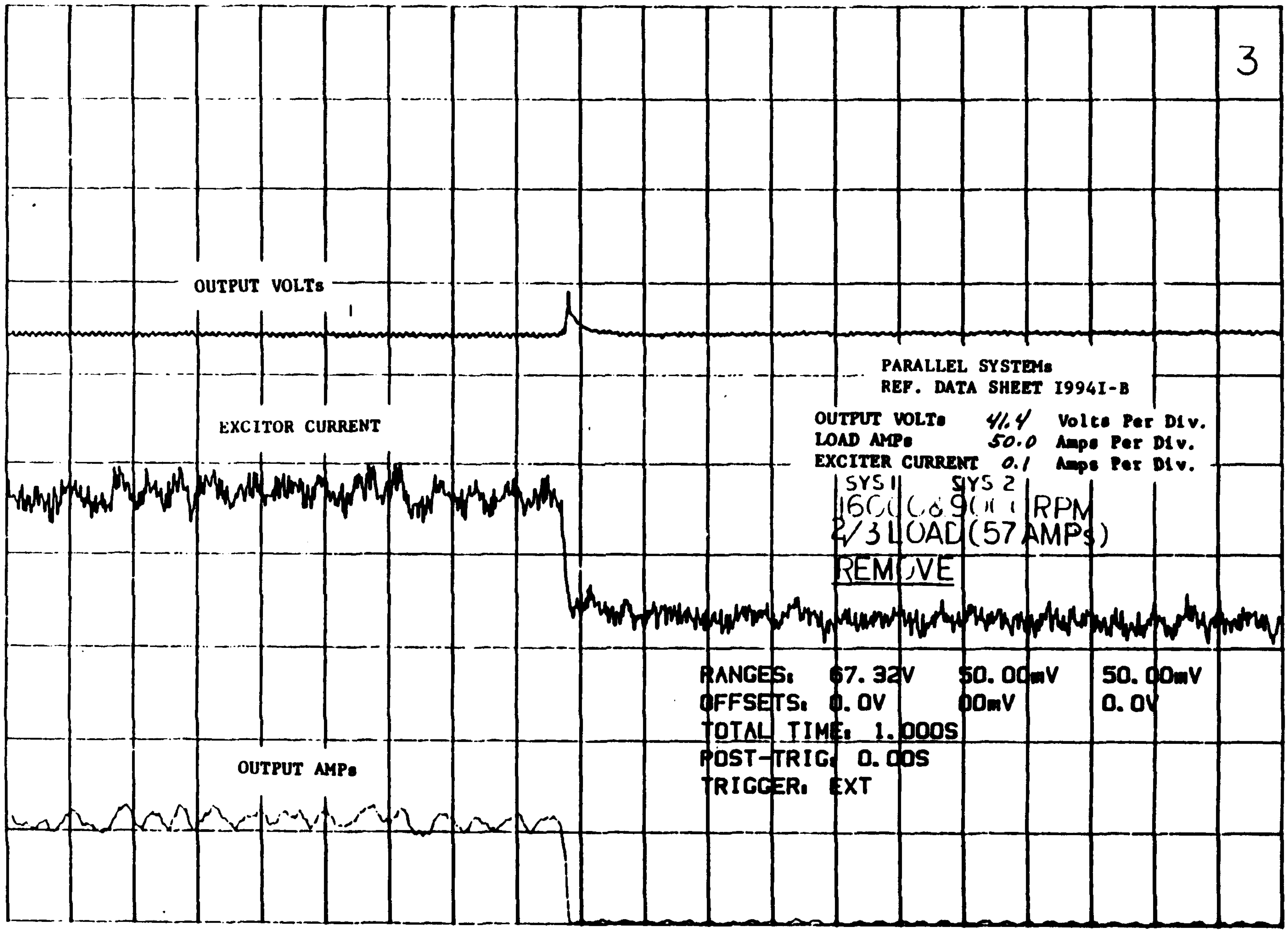
RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
6050	1345	97.9	266.1	88	0.29	52.0	116.6	148.6	219.1	218.3	144.2	133.8	6.0	10	575	3.33	—	—	
6000	1400	99.4	266.1	87	0.29	53.0	123.6	158.7	235.2	233.8	157.0	141.0	6.0	10	585	3.39	—	—	
6000	1405	99.1	266.2	88	0.29	53.0	124.0	168.8	235.9	234.5	152.9	142.6	6.0	10	588	3.4	—	—	
5950	1410	100.4	266.3	88	0.29	53.0	124.2	159.1	236.2	234.7	154.8	142.2	6.0	10.	585	3.39	—	—	
6050	1415	100.0	266.2	87	0.29	53.0	124.0	159.1	236.1	234.6	153.3	142.5	6.0	10.	585	3.35	—	—	
[illegible]																			
[illegible]100	1418	99.4	265.4	85	0.55	102.0	116.1	146.7	230.0	230.4	146.7	135.2	5.0	9.0	460	2.66	—	—	
[illegible]300	1421	100.0	267.5	54	0.29	55.6	110.2	137.7	194.7	201.6	137.8	126.1	5.0	9.0	450	2.60	—	—	
[illegible]00	1425	99.4	265.6	85	0.55	98.0	106.3	133.1	201.5	199.0	135.3	124.4	5.0	9.0	440	2.55	—	—	1
[illegible]00	1431	100.0	265.4	57	0.435	76.0	107.0	133.9	193.6	194.7	134.8	122.5	5.0	9.0	435	2.52	—	—	2
[illegible]250	1434	99.7	267.4	54	0.305	52.0	116.4	132.4	186.9	188.5	132.8	121.5	6.6	8.5	435	2.52	—	—	
[illegible]100	1439	99.0	265.3	57	0.425	72.6	103.2	127.5	171.3	170.2	127.9	117.8	5.0	8.5	430	2.49	—	—	3
[illegible]100	1444	98.8	266.1	25	0.38	63.0	103.2	127.3	166.6	167.7	128.1	117.8	4.0	8.0	420	2.43	—	—	4
[illegible]250	1448	98.4	267.5	54	0.32	53.0	102.2	125.6	161.3	161.6	125.8	116.1	4.0	8.0	420	2.43	—	—	
[illegible]150	1453	97.9	266.1	25	0.37	62.0	100.9	123.6	155.7	155.3	123.7	114.8	4.0	8.0	415	2.42	—	—	5
																			6
5950	1458	99.7	266.4	90	0.3	52.0	108.5	138.2	198.2	192.3	134.6	124.6	6.0	10.	550	3.18	—	—	

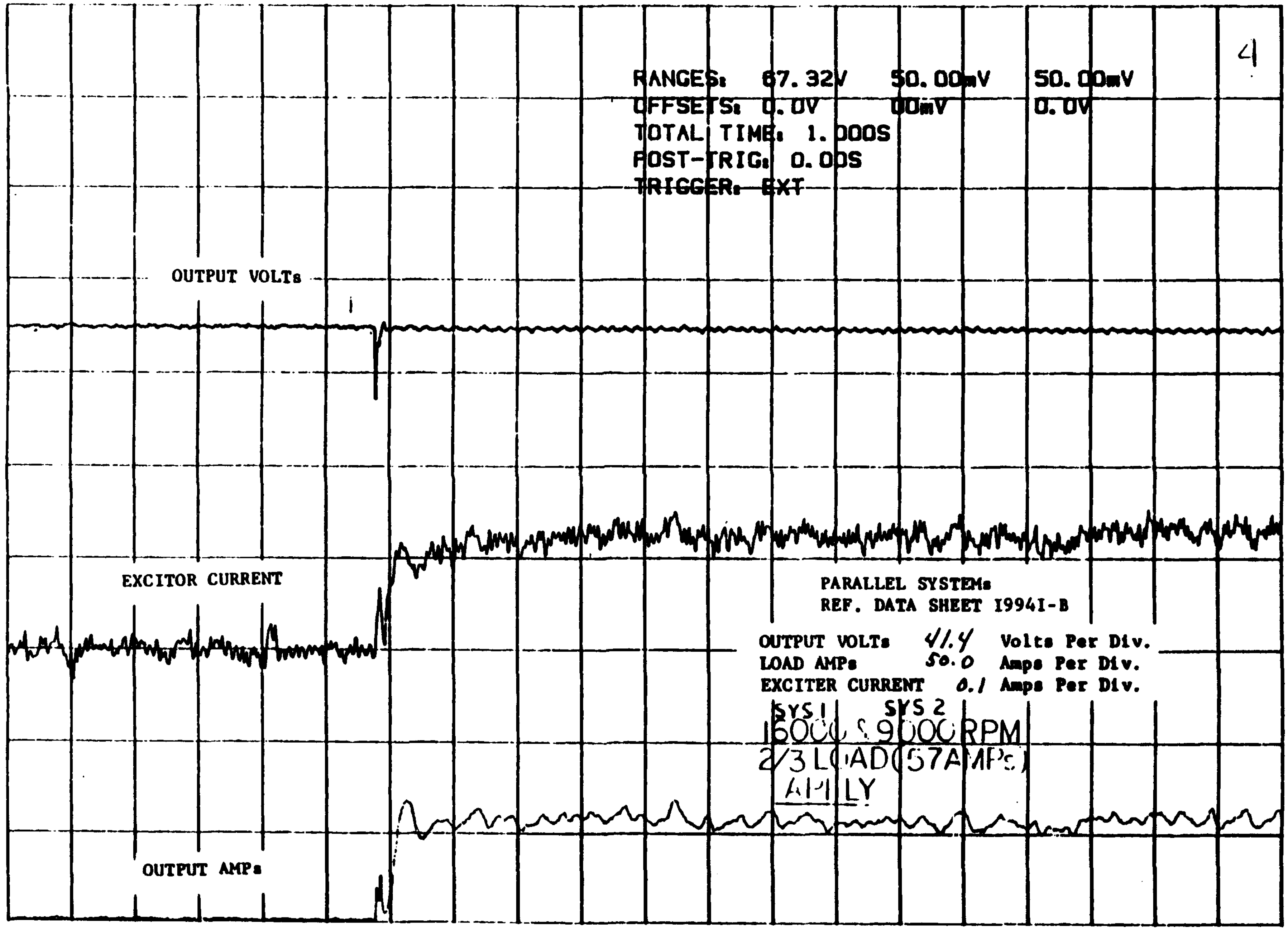
PRECEEDING FOLLOWING

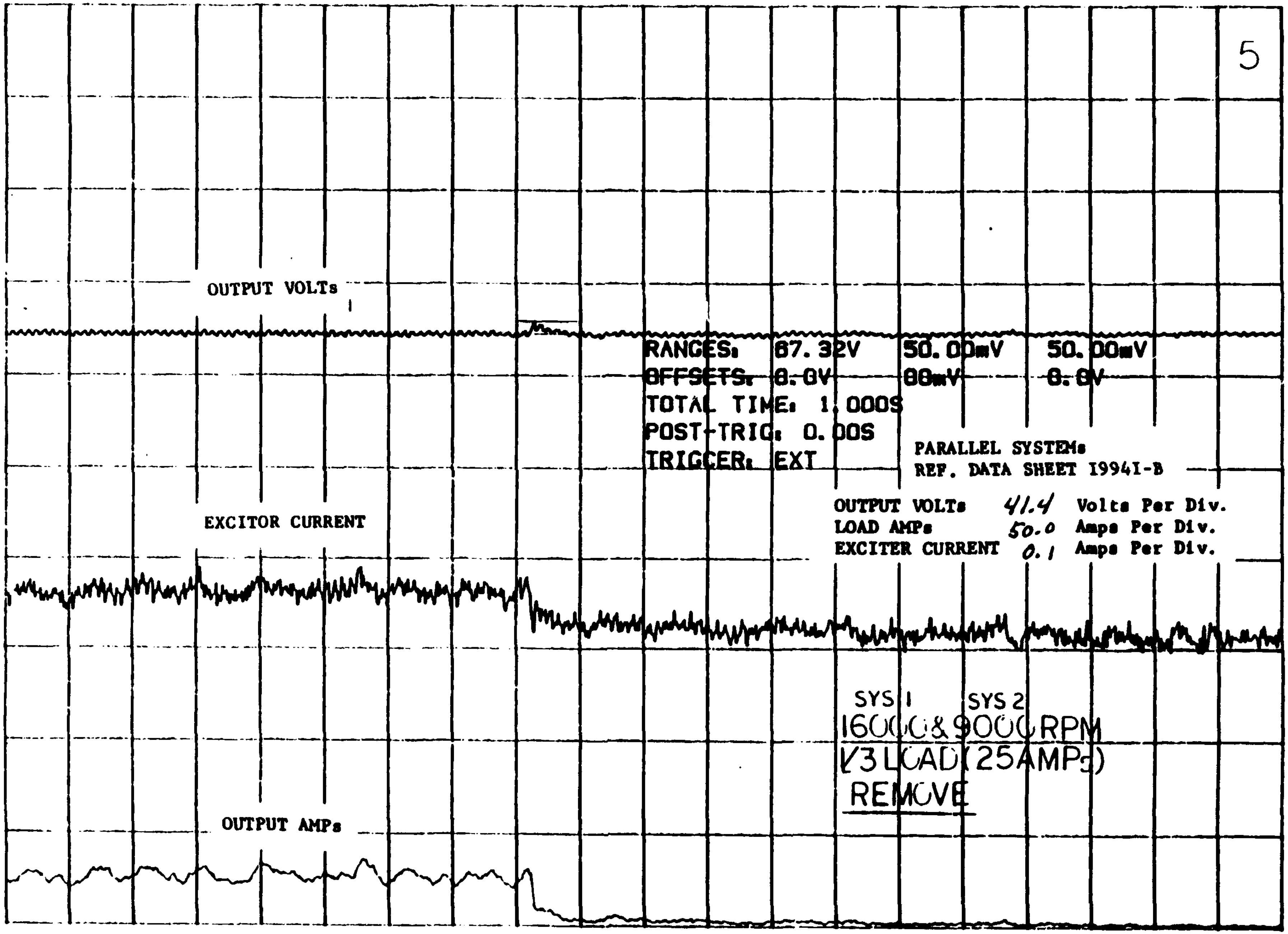


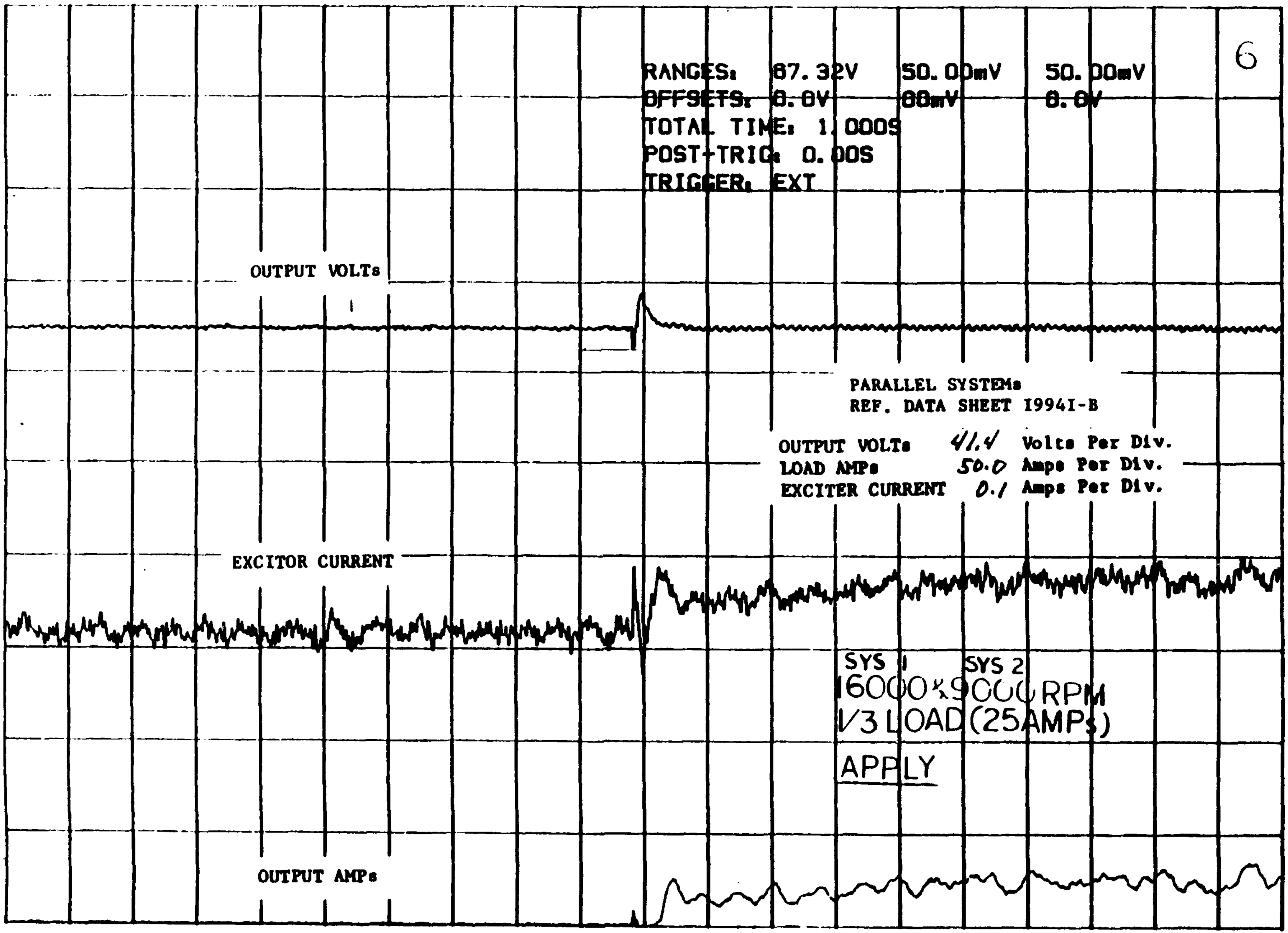
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
FULL LOAD (85 AMPs)
REM VE


2
OUTPUT VOLTs
EXCITOR. CURRENT
OUTPUT AMPs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1
SYS 2
FULL LOAD (85 AMPs)
APPLY


3
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I994I-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
1600 & 900 RPM
2/3 LOAD (57 AMPs)
REMOVE
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT


4
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I994I-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
16000 & 9000 RPM
2/3 LOAD (57AMPs)
APPLY


5
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET 19941-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
16000 & 9000 RPM
1/3 LOAD (25 AMPS)
REMOVE


6
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 80mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
OUTPUT VOLTs
PARALLEL SYSTEMs
REF. DATA SHEET I994I-B
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
SYS 1 SYS 2
16000 X 9000 RPM
1/3 LOAD (25AMPs)
APPLY
OUTPUT AMPs

LUCAS AEROSPACE
POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMATHUK

E.W.O. 54805 MODEL NO. SYSTEM 1 SERIAL NO. GCU 104 / CURRENT 121; GEN XL4 / SENSORS 126 ROTOR NO. STATOR NO.

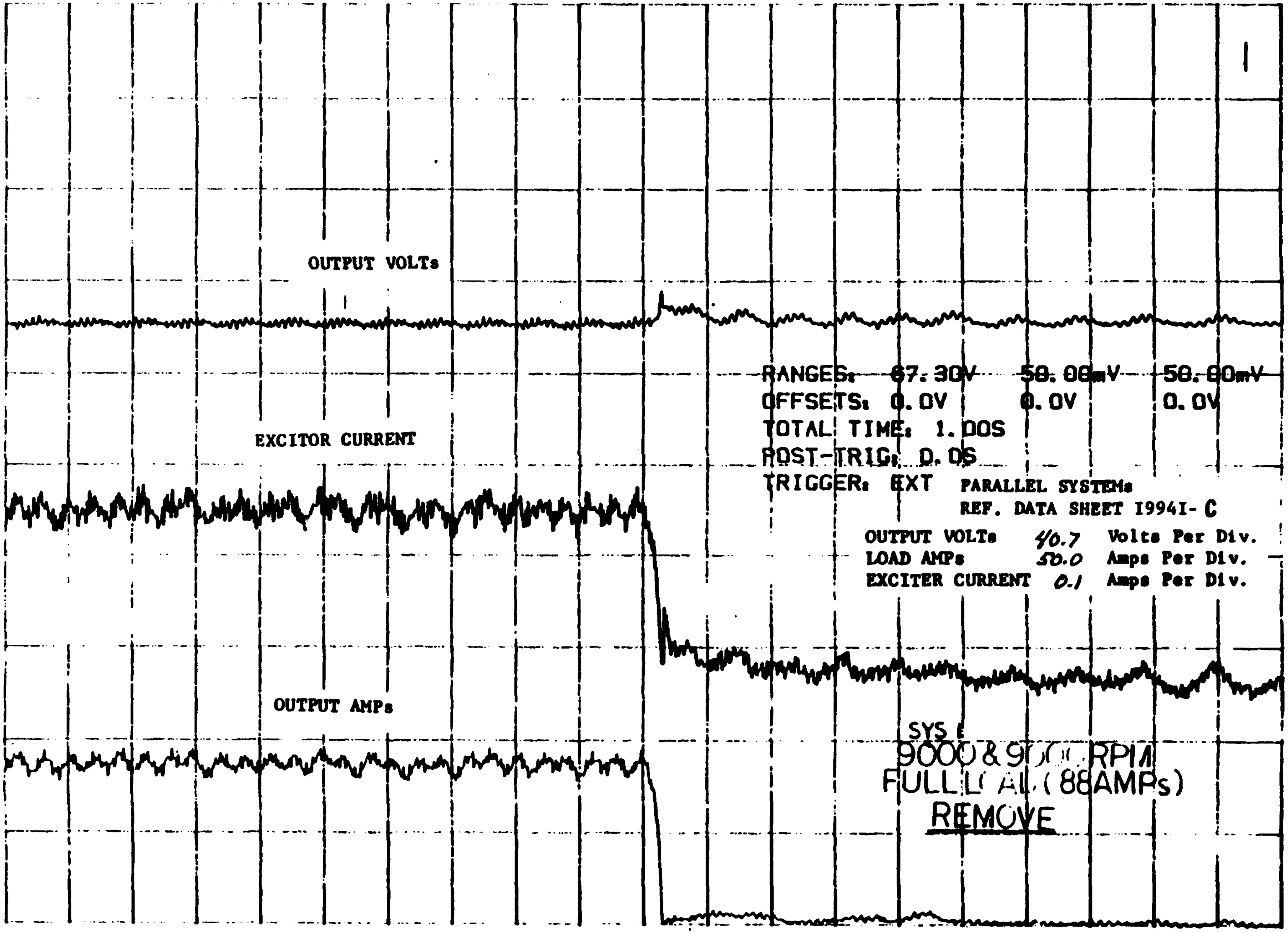
DATE OF TEST 7/15/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

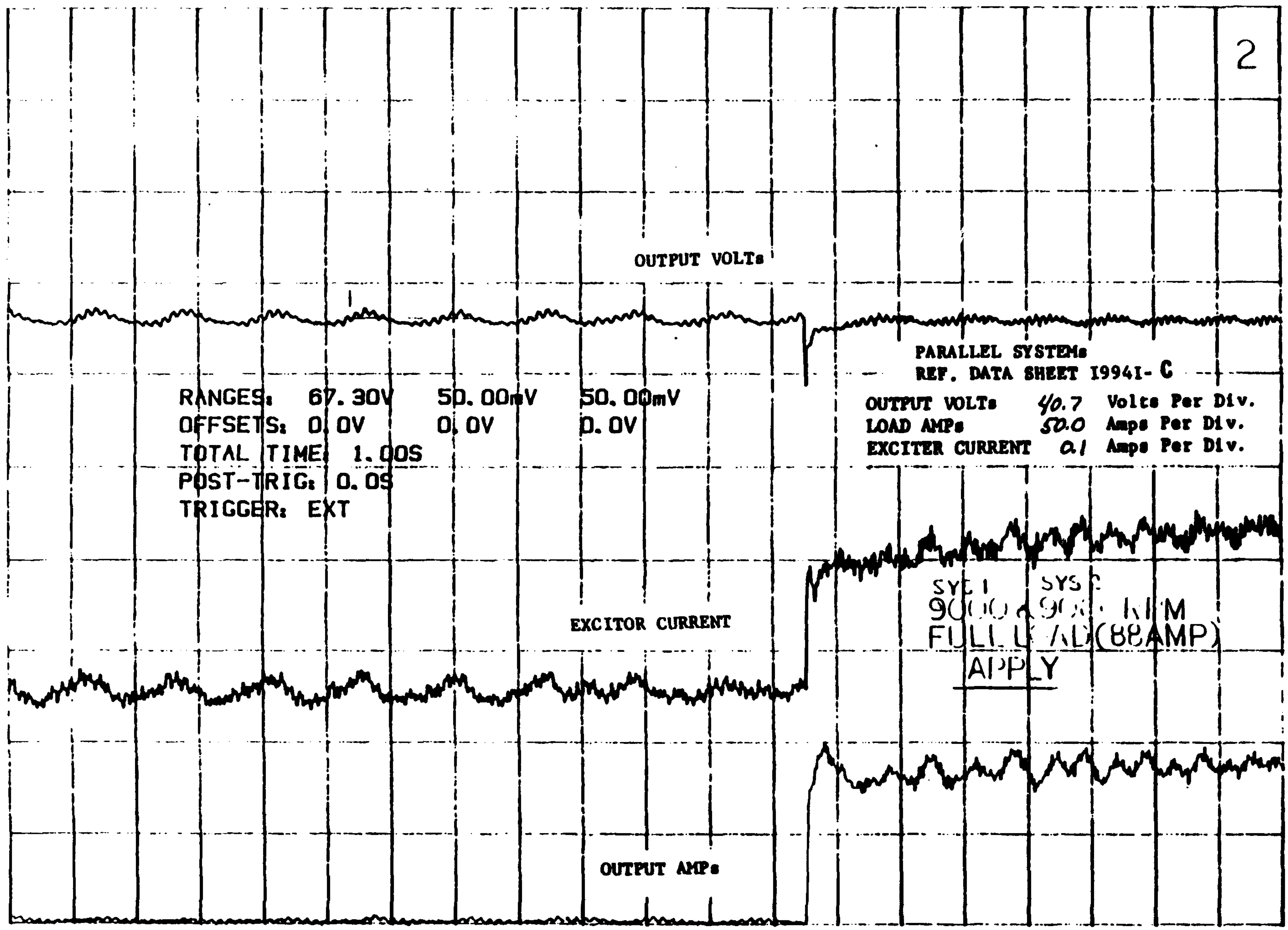
TITLE: 4.9.3 "C" PARALLEL SYSTEMS 9000 & 9000 RPM PAGE OF

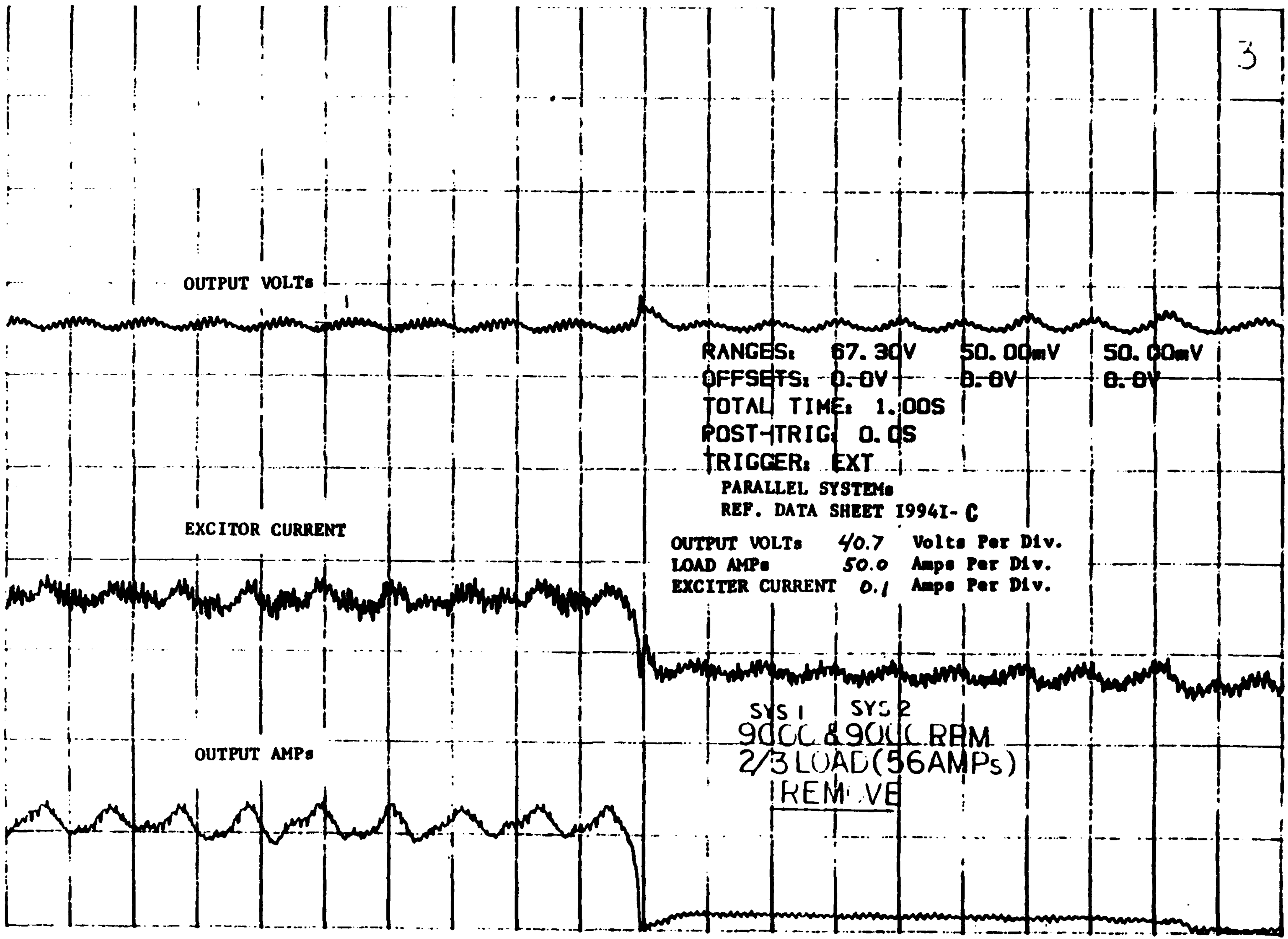
RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITOR AMP	EXCITOR VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
6050	1340	98.0	266.4	86	0.24	42	97.1	127.8	206.0	210.5	126.0	121.7	8.5	14.5	555	321	2.0	2.1	—
6050	1345	103.5	266.4	87	0.24	43	98.9	131.1	216.2	220.5	130.2	124.9	8.5	14.0	555	3.21	2.0	2.2	—
6050	1350	103.2	266.4	87	0.24	43	99.4	132.0	218.8	223.6	131.1	125.6	8.5	14.6	555	3.21	2.0	2.2	—
6050	1355	103.6	266.4	87	0.24	43.5	101.2	133.4	220.5	225.5	132.2	126.5	8.5	14.6	560	3.24	2.0	2.1	—
6050	1400	101.9	266.4	87	0.24	43.5	101.6	133.6	221.7	227.1	133.1	127.2	8.5	14.0	560	3.24	2.0	2.1	—
7050	1404	103.5	265.2	88	0.44	80.0	93.9	126.3	221.5	228.9	125.3	120.2	10.0	13.5	366	2.11	4.2	4.0	—
[illegible]	1406	103.5	267.5	5A	0.26	45.0	93.2	122.5	192.9	196.7	125.2	117.5	12.0	15.5	360	2.08	4.0	4.0	1
[illegible]	1410	103.0	266.1	88	0.431	75.0	90.6	117.8	185.9	192.0	119.0	113.8	14.0	18.0	355	2.06	4.2	4.0	2
[illegible]	1413	102.7	265.5	56	0.36	62.1	90.6	118.7	194.5	198.7	120.3	114.1	14.4	18.0	350	2.03	4.2	4.2	—
[illegible]	1416	105.6	268.0	5A	0.26	43.0	90.5	117.8	182.0	186.0	119.2	113.5	15.0	18.0	355	2.06	4.0	4.0	3
7150	1423	103.1	266.5	56	0.35	58	89.5	114.0	166.4	170.5	114.8	110.8	15.0	18.5	350	2.03	3.5	4.0	4
2050	1427	103.9	266.4	27	0.27	48	89.8	114.4	163.6	166.5	115.1	110.9	15.0	19.0	355	2.06	4.0	4.0	—
7250	1424	105.2	269.6	5A	0.26	42.3	89.8	113.8	157.9	160.3	114.8	110.9	14.5	19.0	356	2.06	4.0	4.0	5
7250	1433	102.6	266.2	27	0.285	47.0	89.2	112.4	151.8	154.4	112.6	109.7	15.0	19.0	360	2.08	4.0	4.0	6

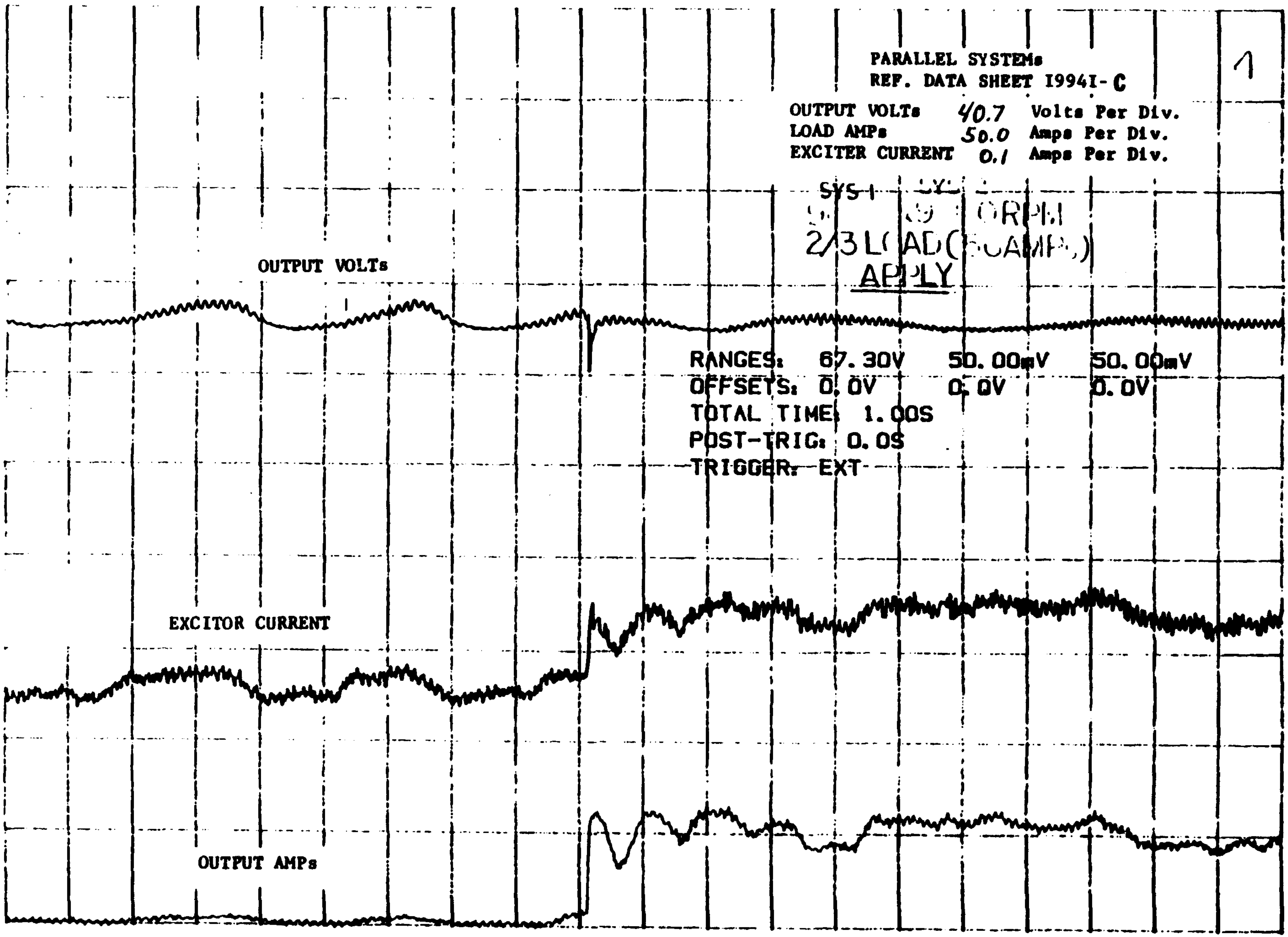
PRECEEDING FOLLOWING



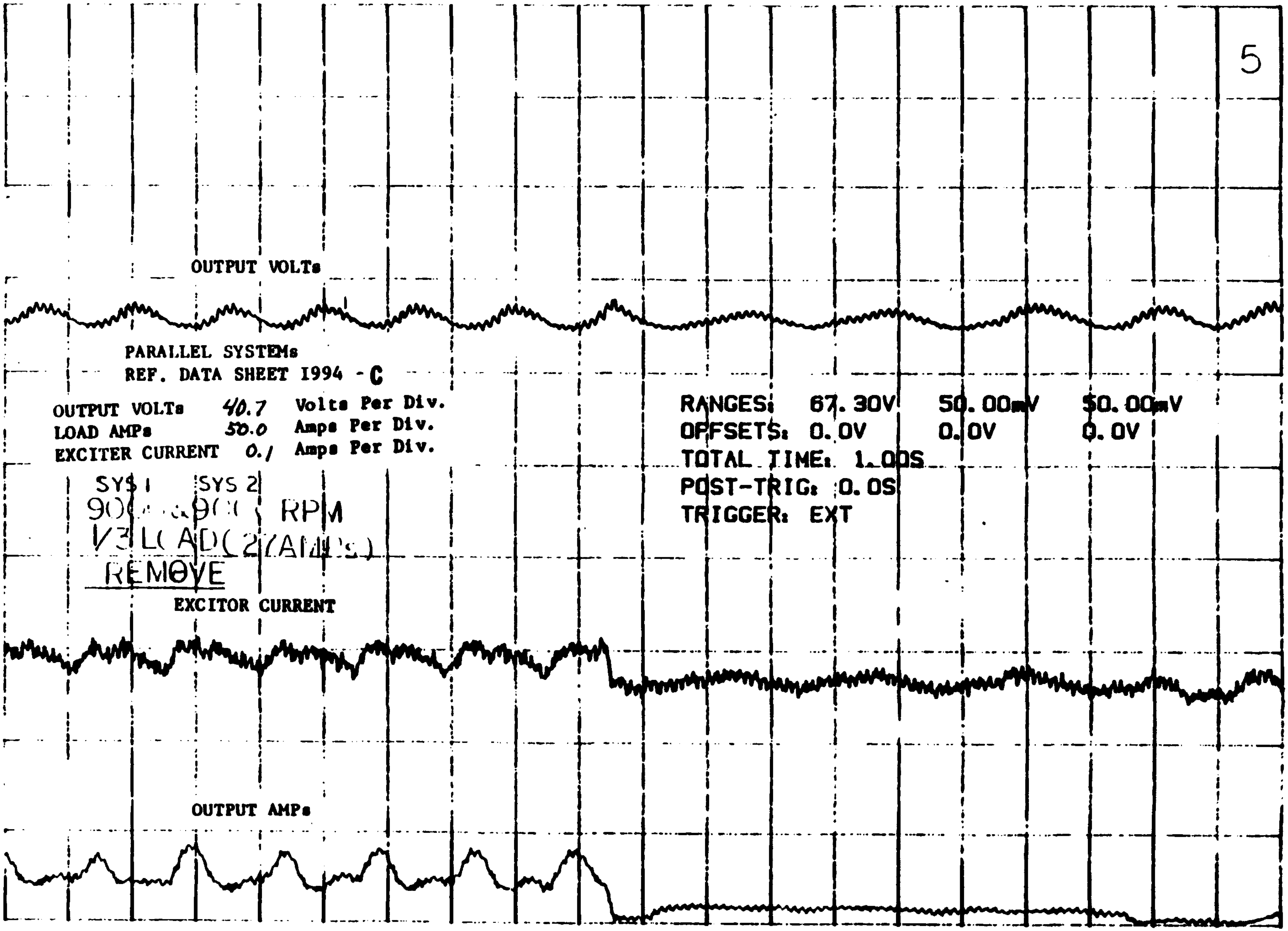
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET 1994I-C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
REMOVE

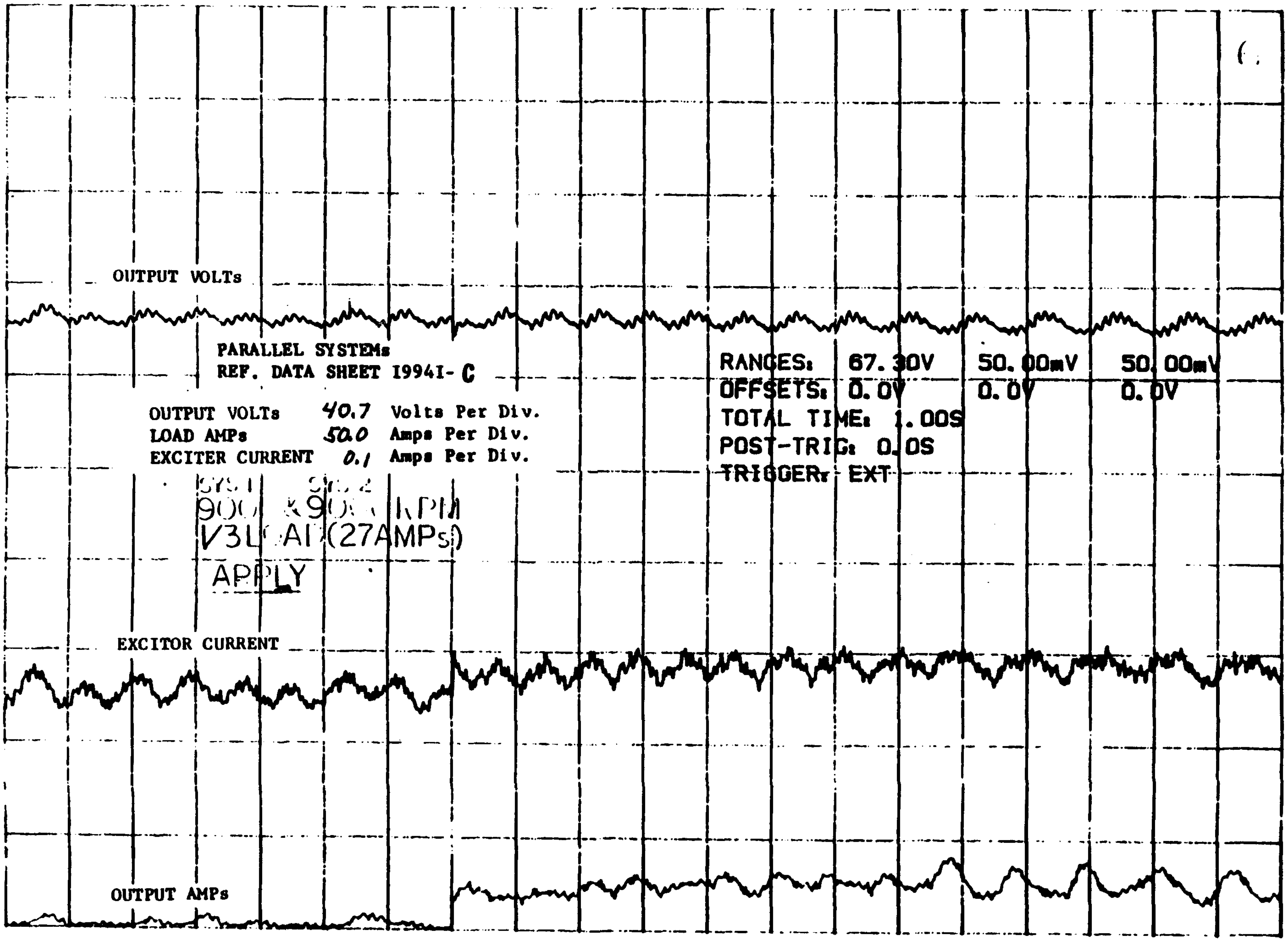

2
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I9941-C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
EXCITOR CURRENT
FULL LOAD (88AMP)
APPLY
OUTPUT AMPs


3
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET 1994I- C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
9000 & 9000 RPM
2/3 LOAD (56AMPs)
REMOVE



PARALLEL SYSTEMs
REF. DATA SHEET I994I-C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
2/3 LOAD
APPLY
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
EXCITOR CURRENT
OUTPUT AMPs


OUTPUT VOLTs
PARALLEL SYSTEMs
REF. DATA SHEET 1994 - C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
REMOVE
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT


OUTPUT VOLTs
PARALLEL SYSTEMs
REF. DATA SHEET 19941- C
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
APPLY
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
EXCITOR CURRENT
OUTPUT AMPs

LUCAS AEROSPACE
POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT/[illegible]

W.O. 54805 MODEL NO. SYSTEM II SERIAL NO. GCU 103 / CURRENT 123 GEN 101 / SENSORS 326 ROTOR NO. STATOR NO.

DATE OF TEST 7/15/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

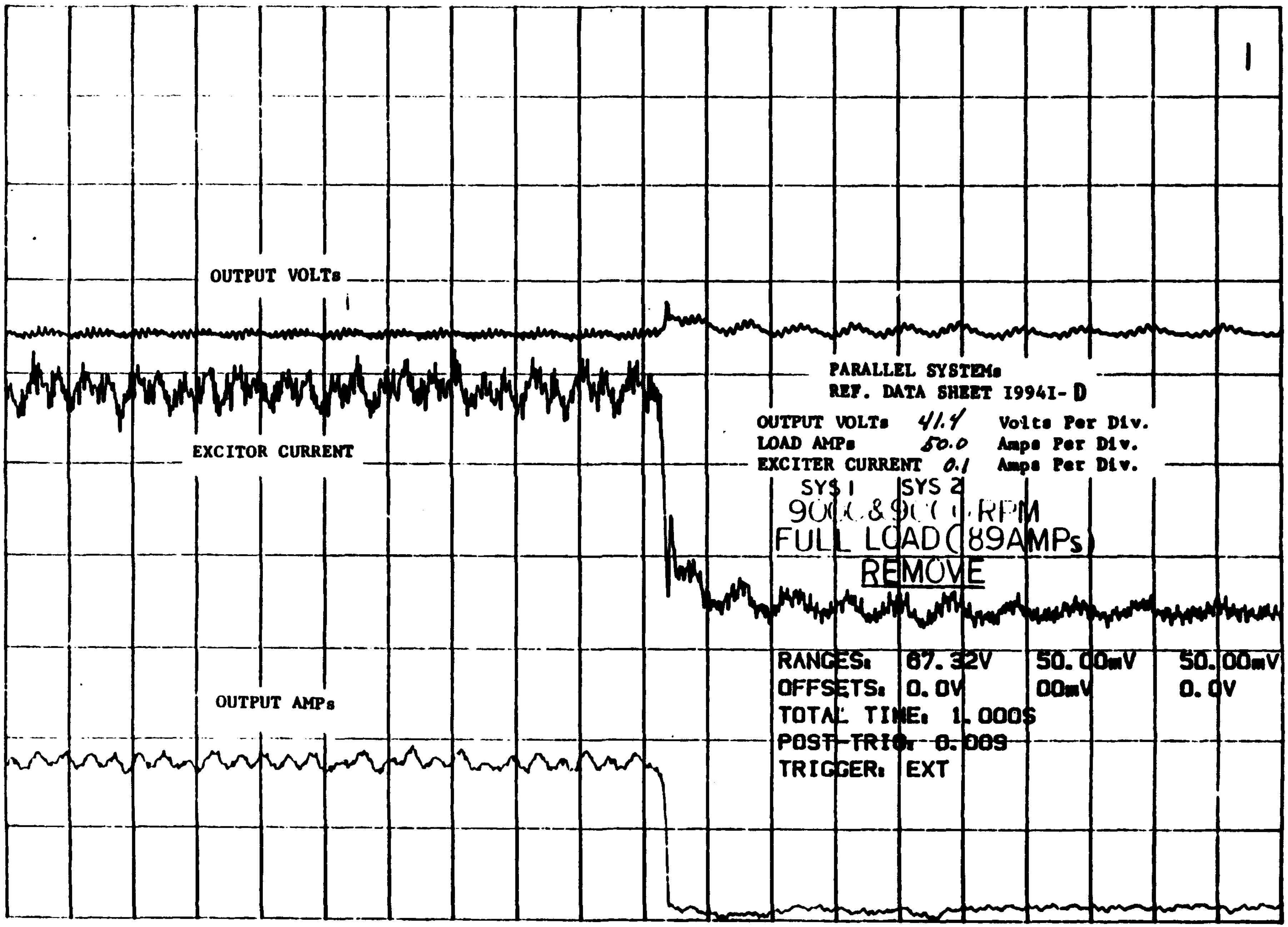
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.9.3 "C" PARALLEL SYSTEMS 9000 & 9000 RPM PAGE OF

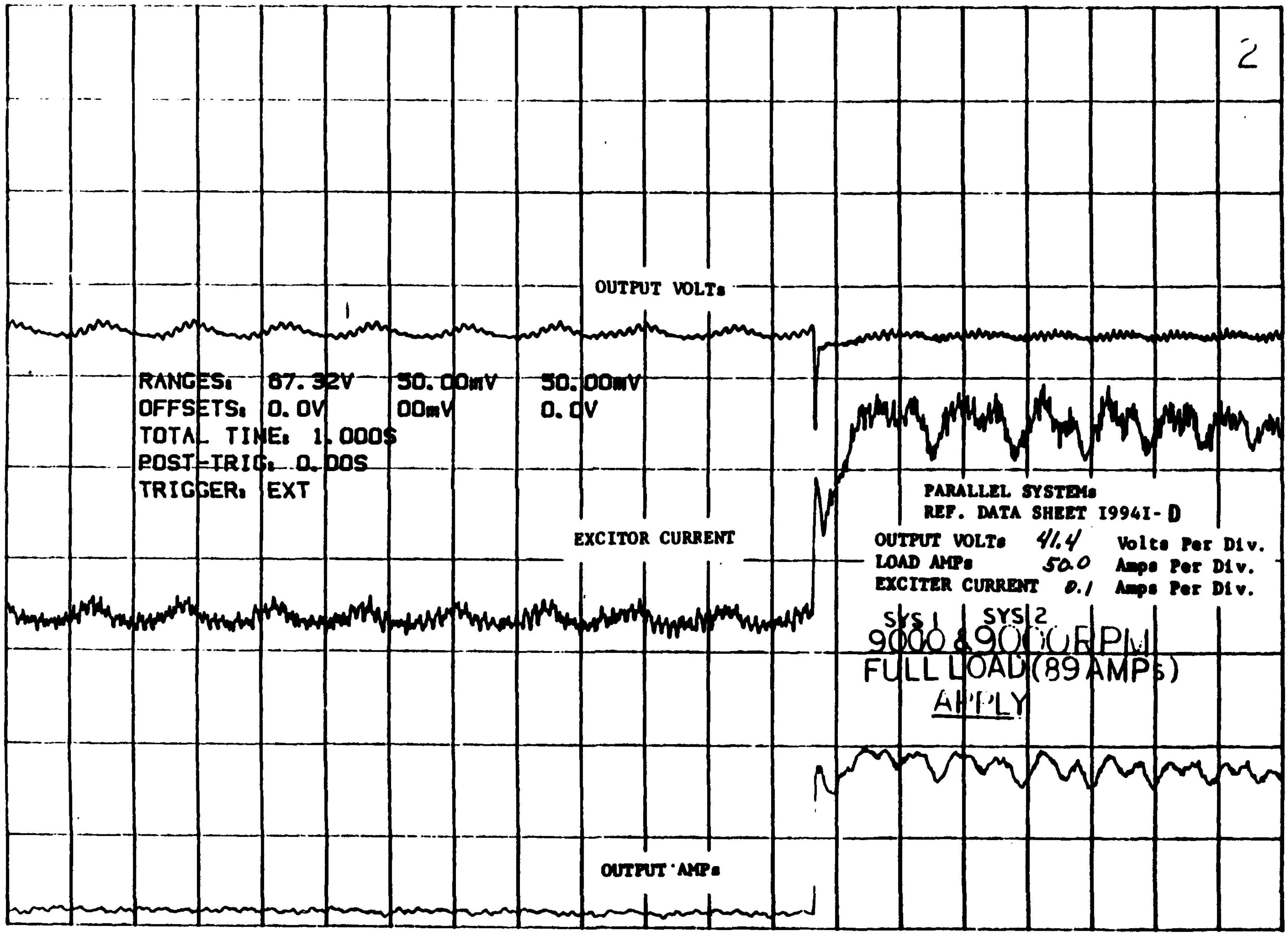
Gs

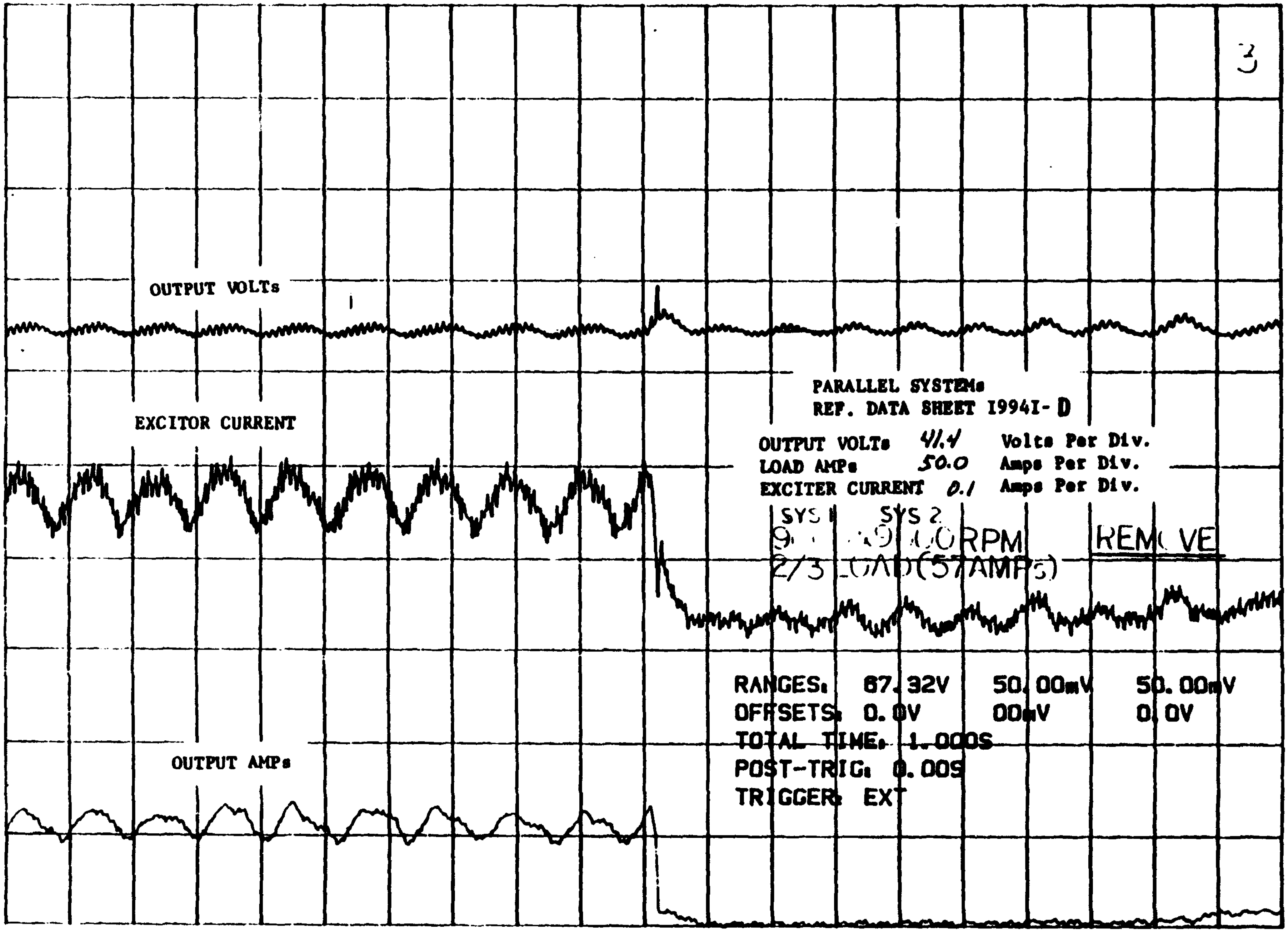
RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
6050	1340	98.0	266.3	89	.295	57.5	119.2	152.9	224.5	221.4	150.0	138.5	6.0	10	560	3.24	—	—	—
6050	1345	103.5	266.2	89	0.295	54.0	122.8	157.7	235.3	233.4	153.9	141.1	6.0	10.5	590	3.42	—	—	—
6050	1350	103.2	266.3	89	0.295	54.0	123.7	158.7	238.4	236.7	155.0	141.6	6.0	10.5	590	3.42	—	—	—
6050	1355	103.6	266.2	89	0.295	54.0	124.6	159.5	239.1	237.7	155.2	142.5	6.0	10.5	585	3.39	—	—	—
6000	1400	101.9	266.3	89	0.295	55.0	124.9	159.7	239.7	238.0	155.2	142.6	6.0	10.5	585	3.39	—	—	—
9050	1404	103.5	265.4	89	0.57	107.5	114.6	144.8	233.3	233.4	147.2	132.4	6.0	9.0	460	2.66	—	—	—
7350	1406	103.5	267.4	SA	0.34	61.0	111.6	139.9	203.7	210.8	142.5	127.9	5.0	9.0	450	2.61	—	—	1
[illegible]	1410	103.0	266.0	89	0.57	101	106.0	132.4	192.8	187.4	135.9	121.3	4.5	8.5	445	2.58	—	—	2
9000	1413	102.7	265.8	56	0.47	83.0	106.9	134.0	206.2	205.9	137.4	122.0	4.5	8.5	435	2.52	—	—	—
7200	1416	105.6	269.1	SA	0.35	60.5	106.3	132.7	190.8	191.1	136.0	122.1	4.5	8.5	435	2.52	—	—	3
9000	1423	103.1	266.0	57	0.47	81.0	103.0	127.5	175.4	173.3	131.6	118.2	4.5	8.5	435	2.52	—	—	4
7100	1427	103.9	266.3	29	0.39	66.0	103.7	128.5	173.0	174.3	132.0	118.6	4.5	8.5	435	2.52	—	—	—
7150	1429	105.2	268.8	SA	0.35	60.0	103.4	127.5	167.0	168.1	130.8	118.1	4.5	8.5	435	2.52	—	—	5
9150	1433	102.6	266.0	29	0.385	64.5	101.9	125.5	160.2	157.8	128.5	116.7	4.5	8.0	435	2.52	—	—	6

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG ______ NO: 19941-D

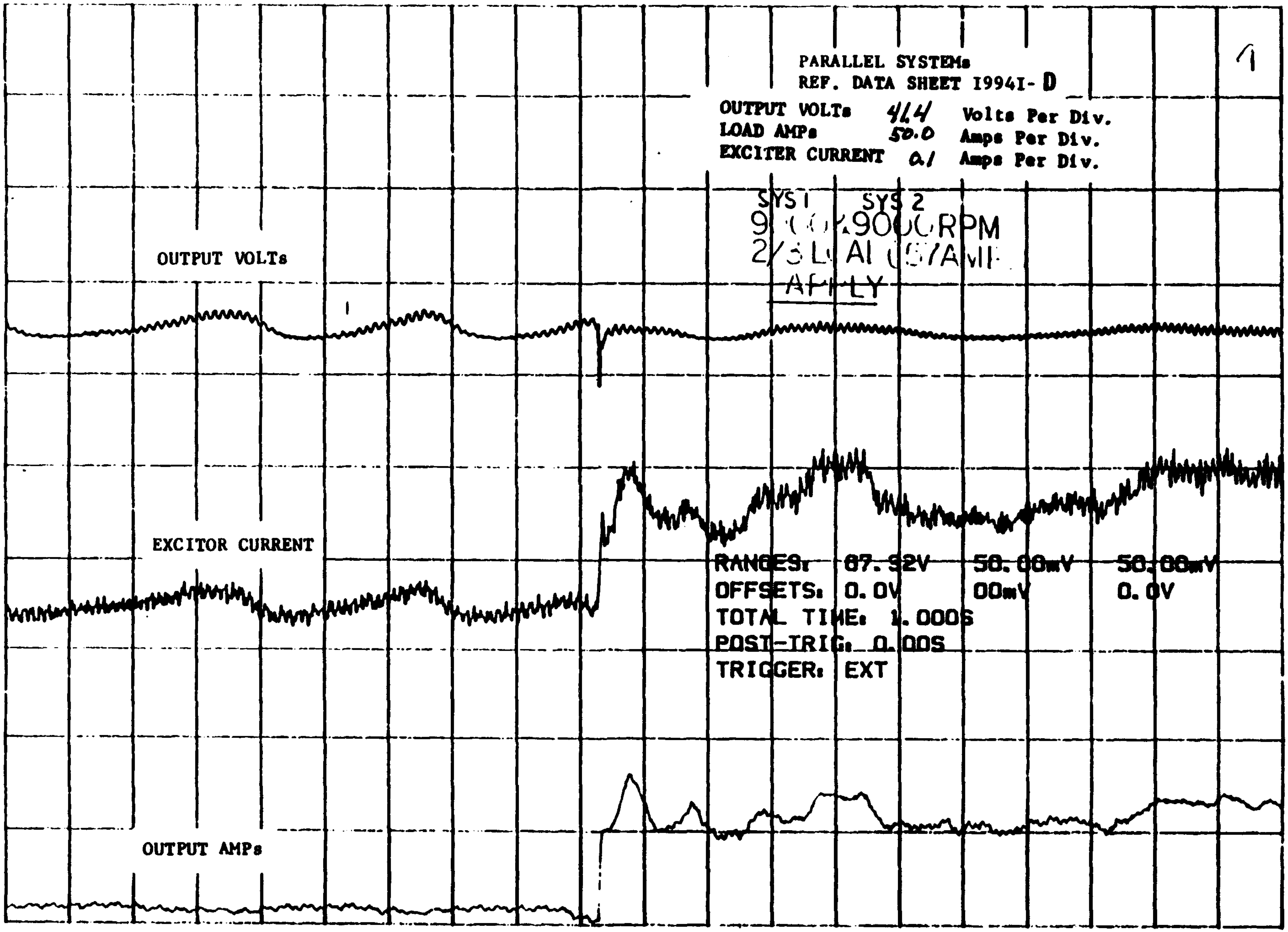


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I9941- D
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
FULL LOAD (89AMPs)
REMOVE
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT

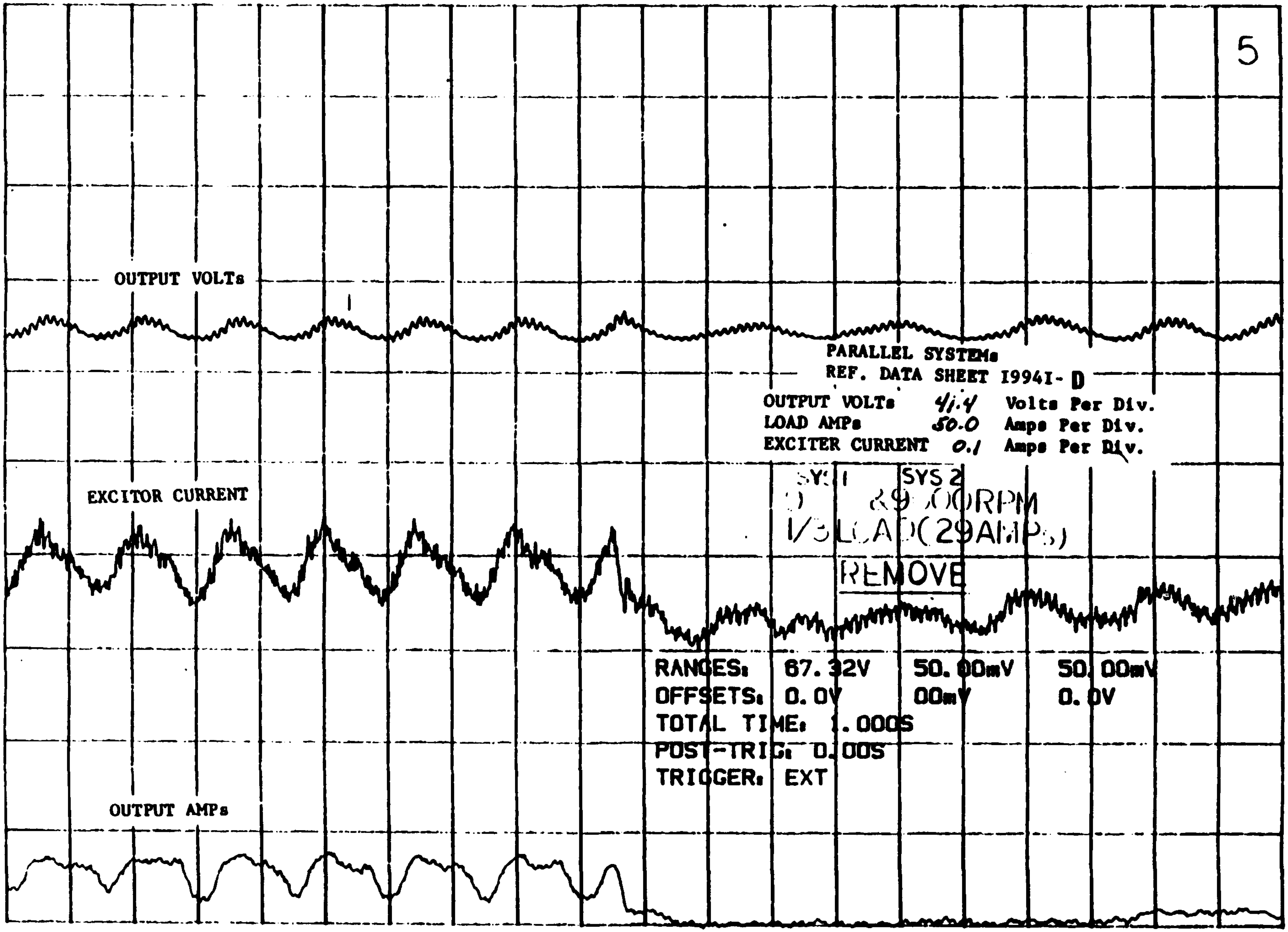

2
OUTPUT VOLTs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
EXCITOR CURRENT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-D
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
9000 & 9000 RPM
FULL LOAD (89 AMPs)
APPLY
OUTPUT AMPs

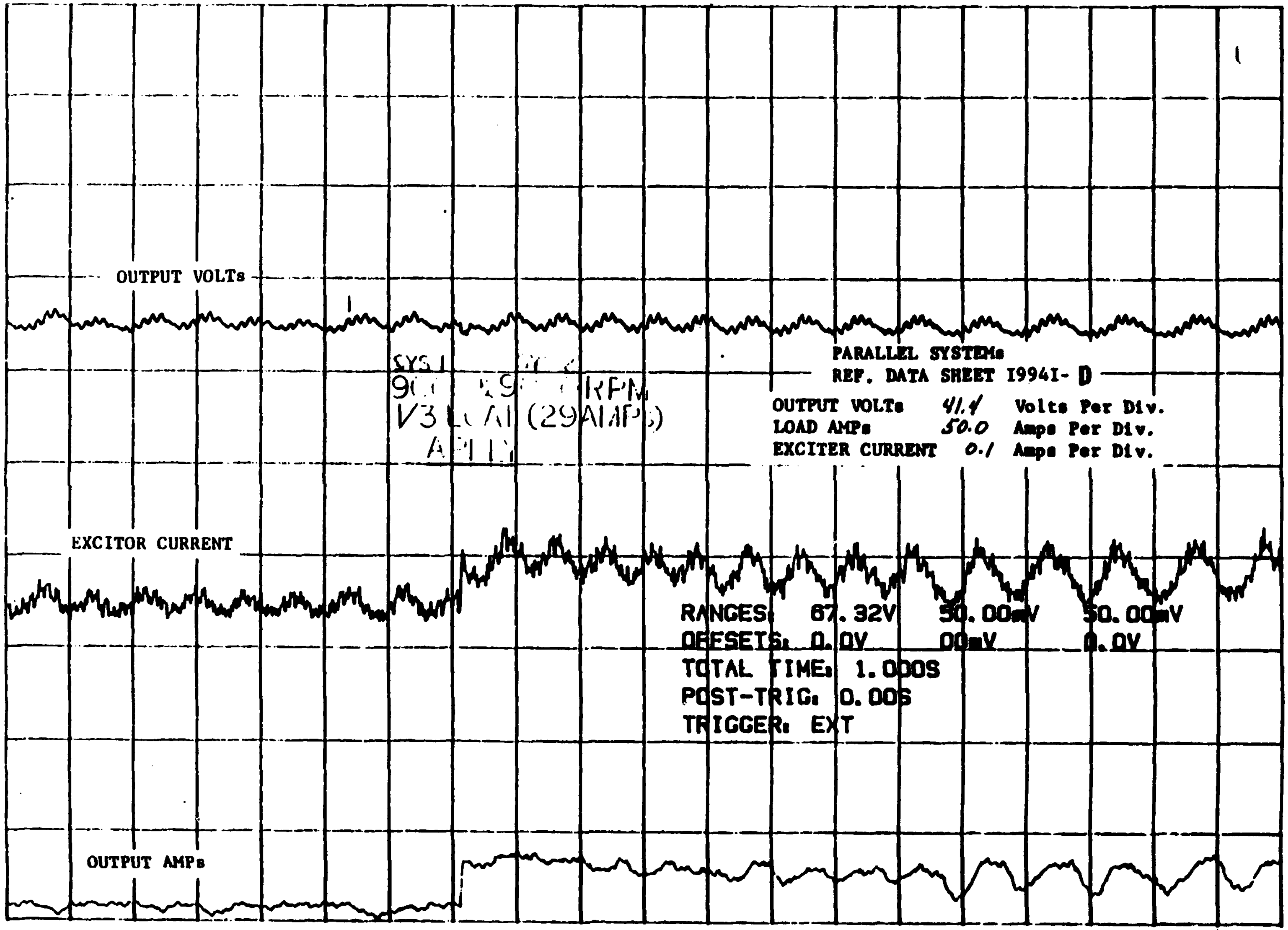


3
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I994I- D
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
REMOVE
2/3 LOAD (57 AMPs)
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT



PARALLEL SYSTEMs
REF. DATA SHEET I994I- D
OUTPUT VOLTs 414 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS1 SYS2
APPLY
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 87.92V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT


5
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I994I- D
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
1/3 LOAD (29AMPs)
REMOVE
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
PARALLEL SYSTEMs
REF. DATA SHEET I994I- D
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
V3 LOAD (29AMPS)
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT

POWER ED P. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 1 SERIAL NO. GCU GEN / CURRENT SENSORS COG. ENGR. HARMA, DERLIK

ROTOR NO. STATOR NO.

DATE OF TEST 7/21/88 TEST LETTER: NO. QP387 TESTED BY R.J. SANIUK

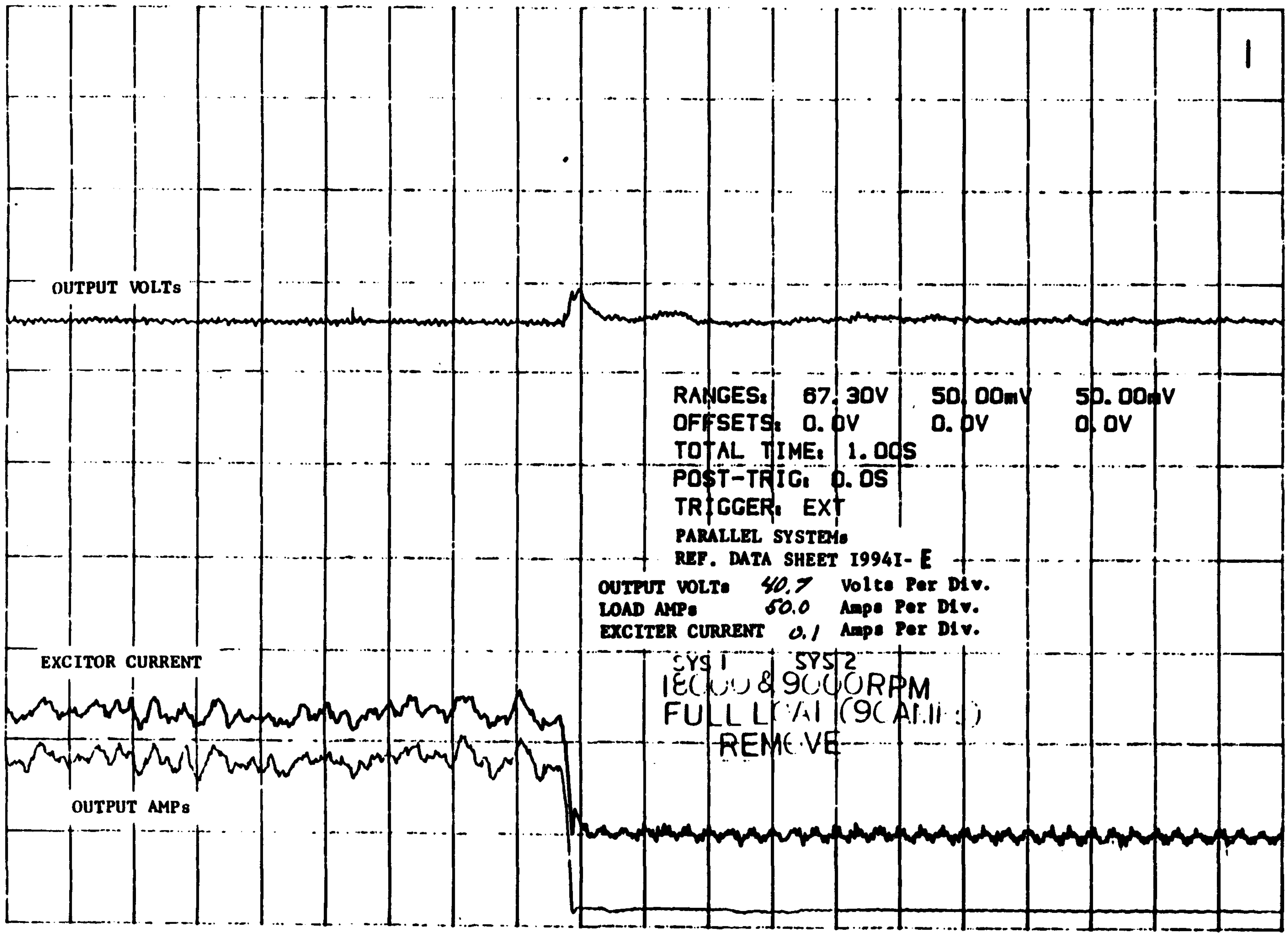
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 493 "C" PARALLEL SYSTEMS 9000 & 18000 RPM. PAGE OF

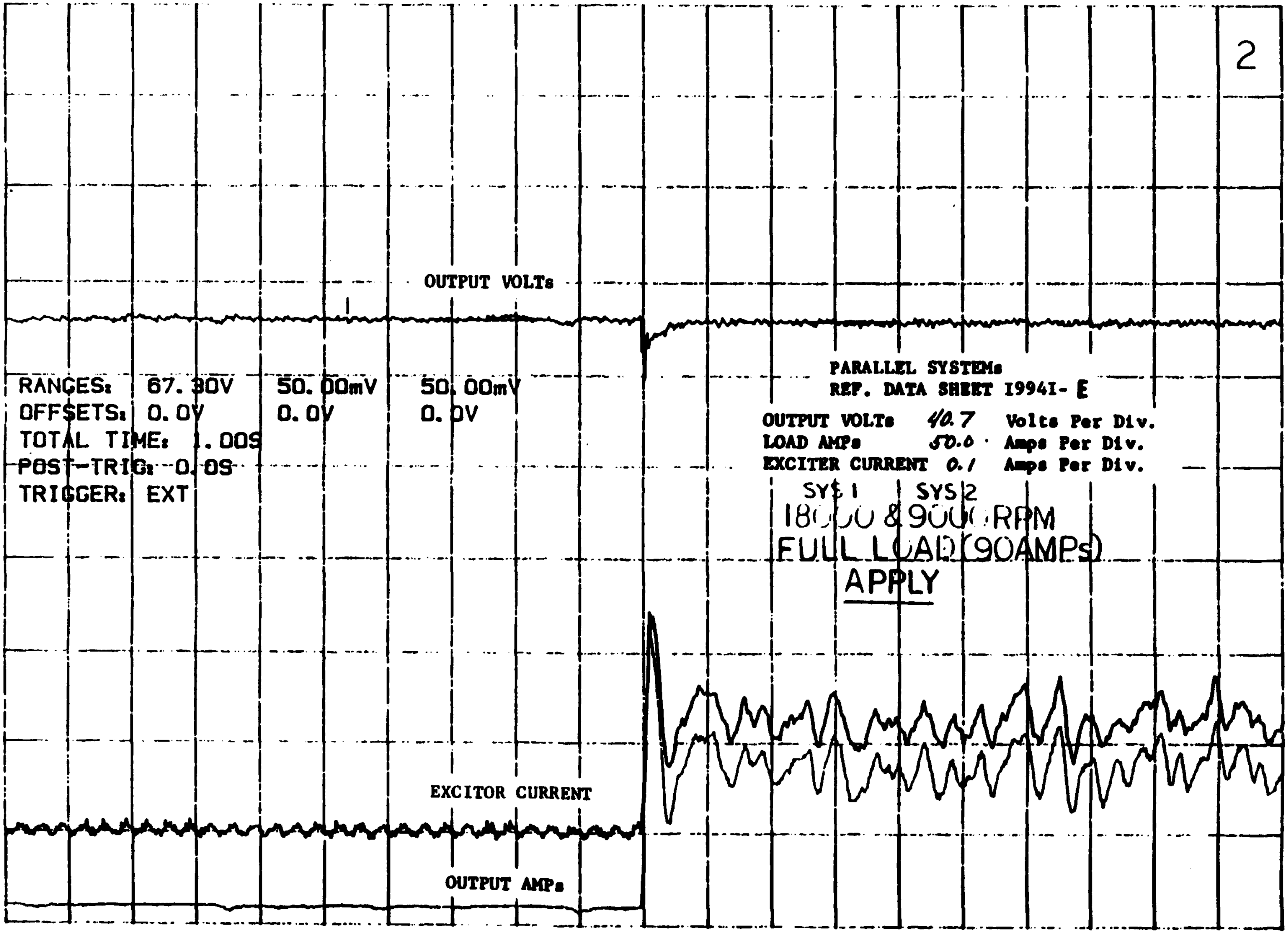
PARA. NO. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16150	0925	79.4	266.4	87	0.230	41.5	96.7	119.8	182.8	188.4	118.6	108.0	9.0	14.9	545	3.3	2.1	2.0	
16150	0930	79.8	266.5	86	0.230	42.0	95.4	126.6	202.4	211.6	116.3	114.4	8.5	14.5	545	3.3	2.1	2.2	
16050	0940	82.0	266.6	86	0.230	42.5	96.4	128.8	214.3	218.6	120.3	116.1	8.5	14.5	550	3.33	2.0	2.1	
16050	0945	82.5	266.6	86	0.230	42.5	96.2	128.9	215.0	219.2	120.4	116.9	8.5	14.6	550	3.33	2.0	2.0	
16100	0950	82.1	266.5	86	0.230	43.0	96.2	128.8	215.1	219.4	119.4	117.1	8.5	14.5	550	3.33	2.0	2.0	
18000	0954	82.5	266.0	90	0.23	42.3	98.3	132.7	216.1	226.8	122.0	119.8	9.1	15.0	580	5.51	2.4	3.0	
18240	0956	82.5	267.5	54	0.10	18.5	99.1	133.8	205.9	213.1	122.3	121.3	9.0	15.0	580	5.51	2.5	2.5	1
17500	1000	82.1	266.1	90	0.23	42.0	97.1	129.3	188.4	192.4	120.4	119.1	9.0	15.0	575	3.48	2.4	2.5	2
17500	1005	82.6	265.9	60	0.18	32.0	97.5	130.4	194.2	202.0	121.6	119.0	9.0	15.0	575	3.48	2.4	3.0	
17550	1008	82.5	267.4	5	0.10	18.0	98.0	130.0	180.3	186.3	120.7	119.2	9.0	15.0	575	3.48	2.5	2.0	3
17550	1011	82.8	265.9	60	0.18	32.0	97.2	128.3	178.5	180.3	119.2	118.7	9.0	15.0	575	3.48	2.2	2.6	4
18950	1015	83.0	266.1	31	0.13	23.0	97.4	129.4	180.4	186.9	119.9	119.0	9.0	15.0	575	3.48	2.1	2.2	
18100	1018	82.6	267.4	54	0.1	18.0	98.8	128.8	180.8	182.1	120.1	118.1	9.0	15.0	575	3.48	2.5	2.5	5
17900	1022	82.8	266.3	31	0.13	23.0	96.7	127.9	170.2	175.4	119.0	117.8	9.0	15.0	575	3.48	2.2	2.2	6
16100	1027	83.3	266.3	87	0.24	42.0	95.9	126.7	159.3	202.7	117.8	116.1	8.5	14.5	550	3.33	2.0	2.0	

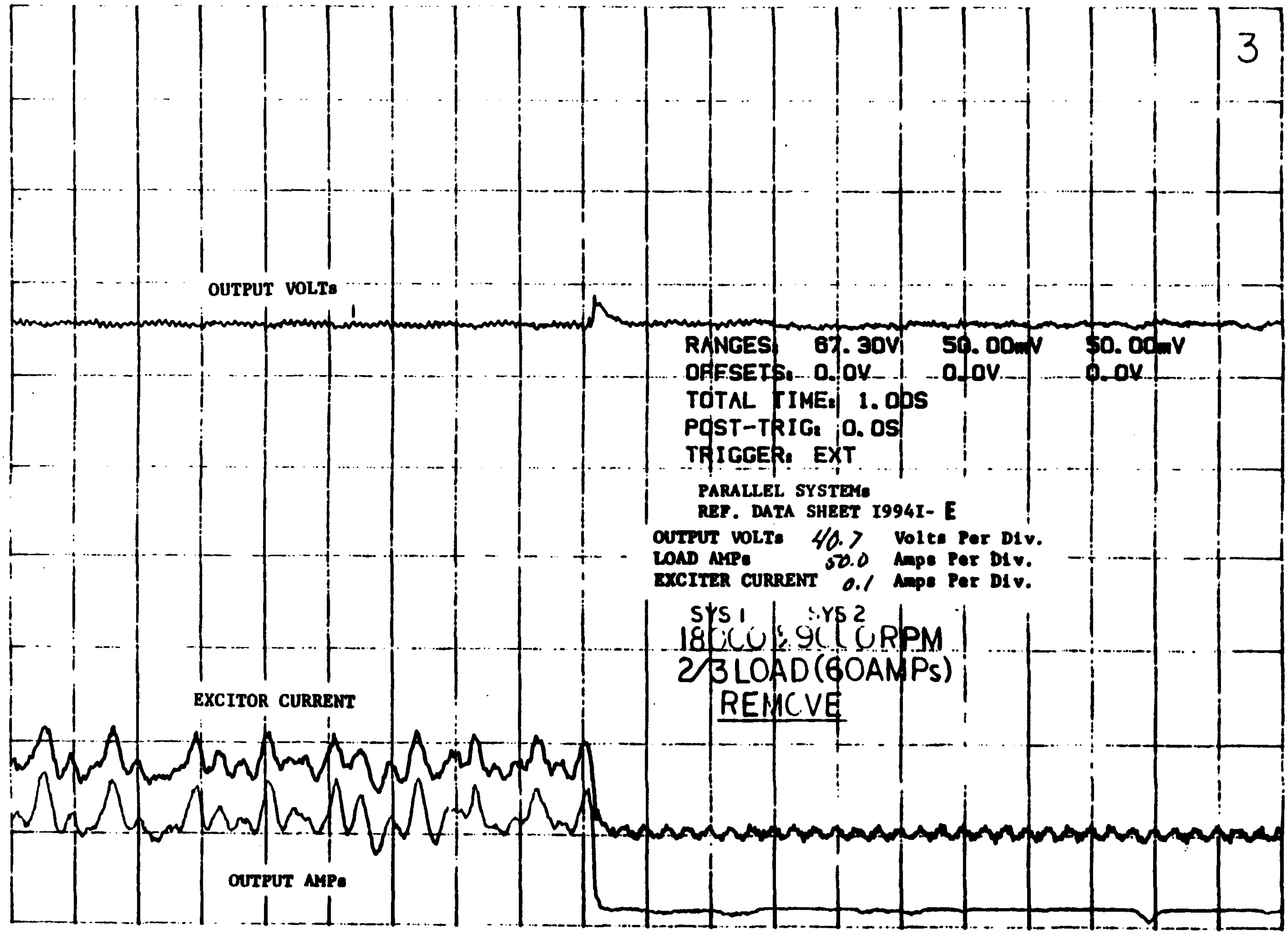
FORM 1349 R/S (12/67) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG

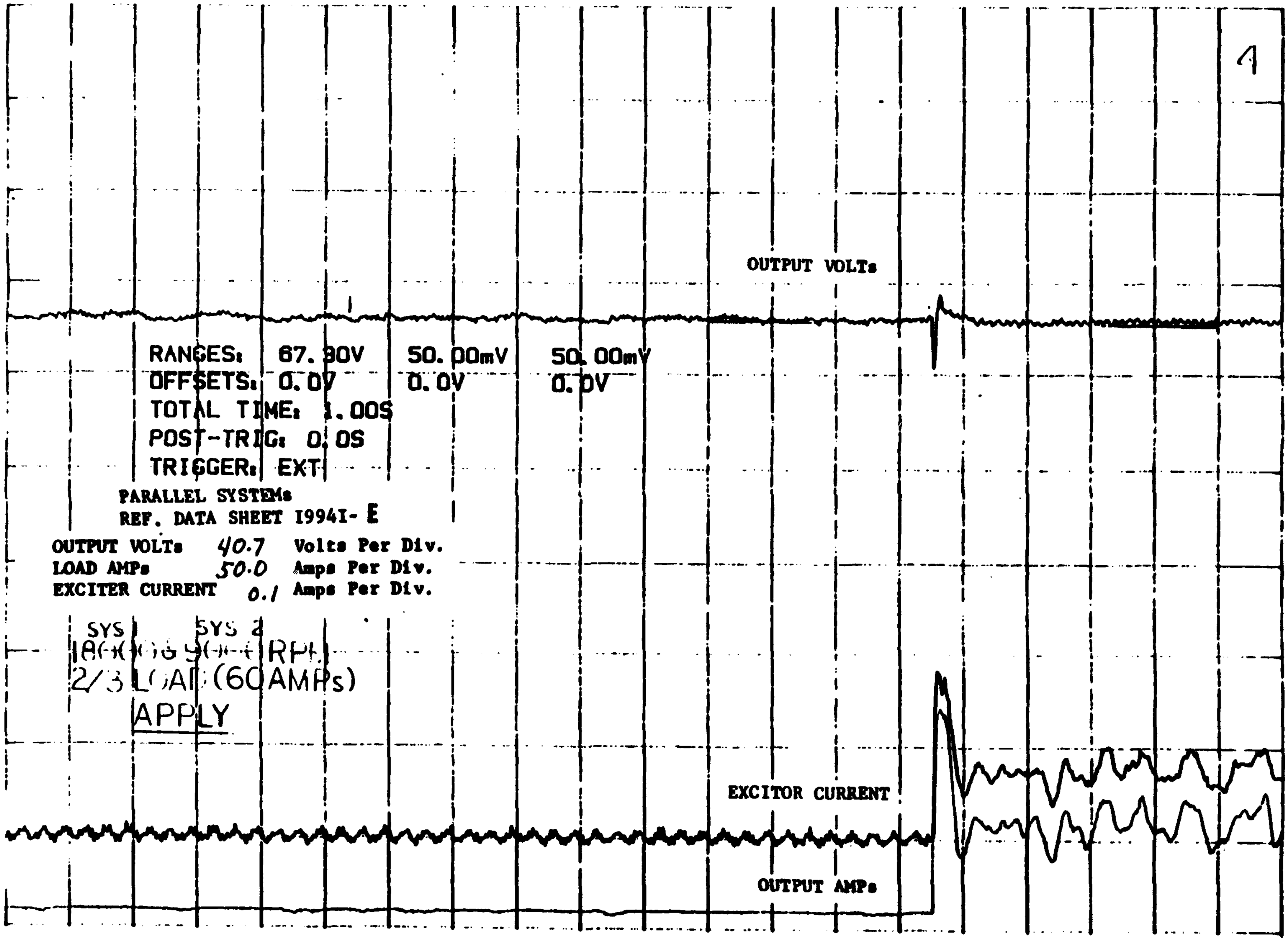
NO: 19941-E



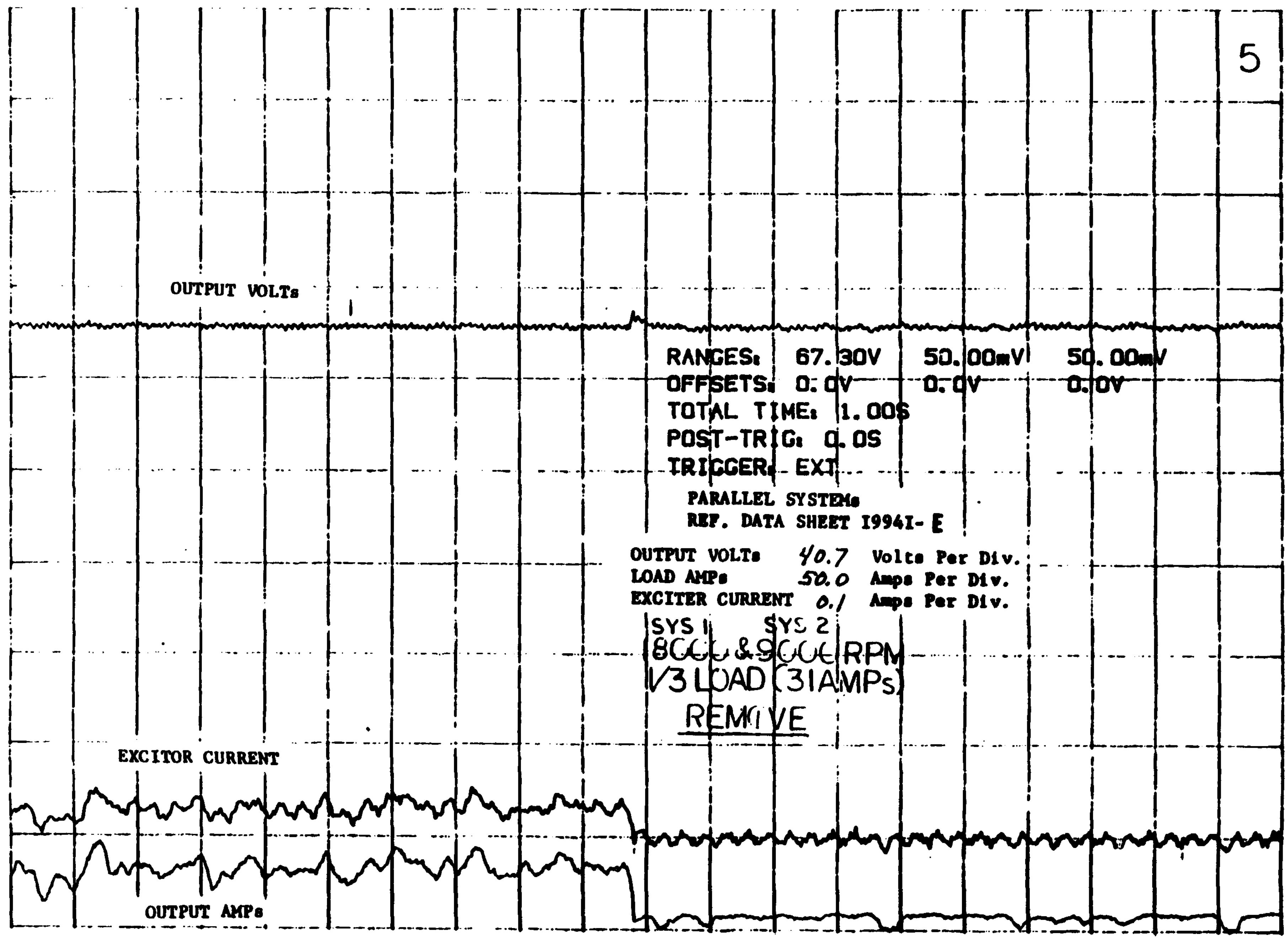
1
OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I-E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2

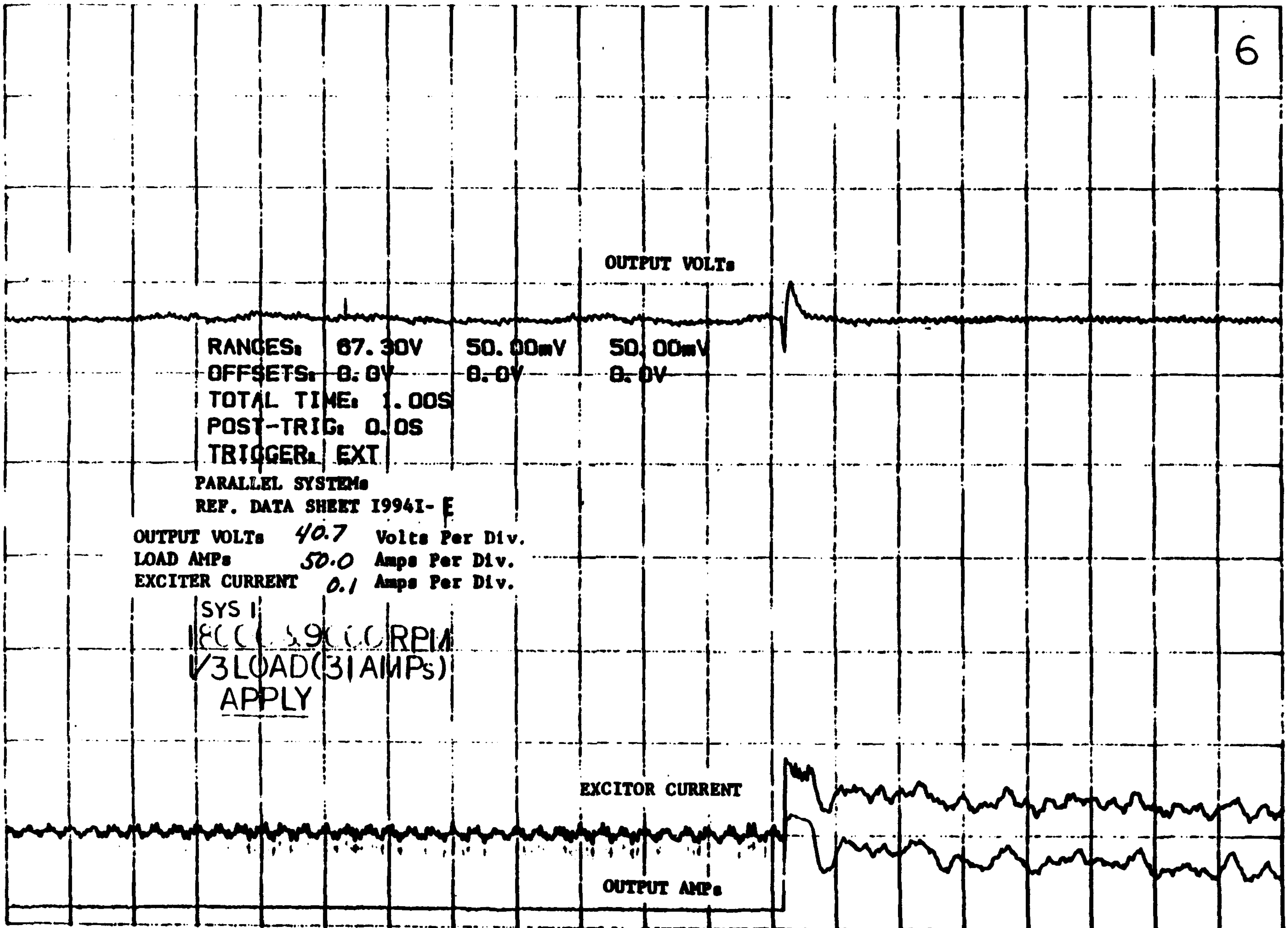

2
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET 1994I- E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
RPM
FULL
(90AMPs)
APPLY
EXCITOR CURRENT
OUTPUT AMPs


3
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I- E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
1800 & 900 RPM
2/3 LOAD (60AMPs)
REMOVE
EXCITOR CURRENT
OUTPUT AMPs



4
OUTPUT VOLTs
RANGES: 67.80V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I- E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
2/3 LOAD (60 AMPs)
APPLY
EXCITOR CURRENT
OUTPUT AMPs


5
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET I994I- E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS 1 SYS 2
(8000 & 9000 RPM
1/3 LOAD (31AMPs)
REMOVE
EXCITOR CURRENT
OUTPUT AMPs


6
OUTPUT VOLTs
RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT
PARALLEL SYSTEMs
REF. DATA SHEET 1994I- E
OUTPUT VOLTs 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
SYS I
1/3 LOAD (31 AMPs)
APPLY
EXCITOR CURRENT
OUTPUT AMPs

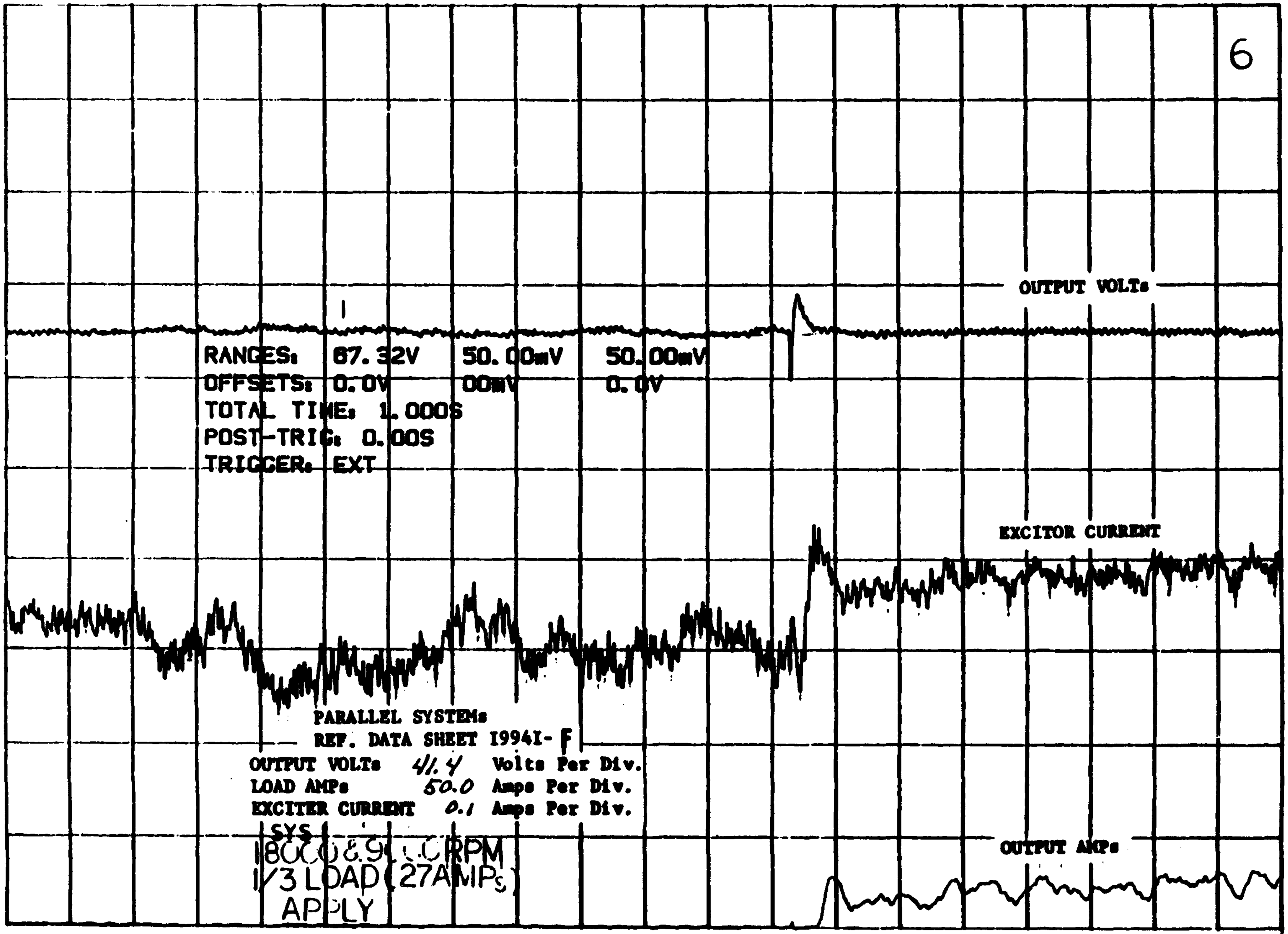
[illegible] TEST LETTER NO. [illegible] TESTED BY K. V. [illegible]

BRUSH GRADE | BAR. PRESSURE | M.P. AIR GAP | I.P. AIR GAP

TITLE: 4.93 "C" PARALLEL SYSTEMS 9000 & 18000 RPM. | PAGE | OF

PARA. IND. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITOR AMP	EXCITOR VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16000	0925	79.4	266.1	90	0.294	57.0	108.8	140.4	199.2	193.7	153.7	129.3	5.5	10.0	530	3.07	—	—	
15950	0930	79.8	266.2	90	0.295	52.5	115.2	149.7	225.8	223.7	140.5	137.4	5.5	10.0	540	3.13	—	—	
15550	0940	82.0	266.2	90	0.295	53.5	117.8	153.3	234.4	233.1	148.0	140.4	5.0	10.0	555	3.21			
15950	0945	82.5	266.3	89	0.295	53.5	117.8	153.3	234.4	233.1	149.3	140.2	5.8	10.0	545	3.16			
15950	0950	82.1	266.3	90	0.295	53.5	117.4	153.1	234.2	233.0	143.7	140.8	5.0	10.0	545	3.16	—	—	
9050	0954	82.5	265.7	85	0.565	103.0	110.8	142.2	227.7	228.4	139.3	131.0	5.0	8.5	425	2.46			
9350	0956	82.5	267.5	64	0.30	53.0	107.9	138.0	213.8	218.9	134.2	127.8	5.0	8.5	420	2.43			1
9050	1000	82.1	265.9	86	0.56	97.5	101.2	127.8	174.9	172.2	126.5	112.8	4.5	8.0	410	2.37			2
9000	1005	82.6	265.6	57	0.47	81.0	102.5	130.4	189.1	189.9	128.4	118.7	4.0	8.0	405	2.34			
9250	1008	82.5	267.5	54	0.315	52.6	101.8	128.4	174.4	172.9	126.6	118.4	4.0	8.0	405	2.34			3
9050	1011	82.8	265.7	57	0.46	77.0	99.0	123.9	158.8	157.7	121.9	113.8	4.0	8.0	405	2.34			4
9050	1015	83.0	266.1	27	0.39	65.5	99.8	125.5	169.4	170.7	123.9	114.6	4.0	8.0	400	2.32			
9000	1018	82.6	267.7	54	0.31	51.6	98.8	123.8	160.8	162.1	122.1	114.1	4.0	8.0	380	2.26			5
9650	1022	82.8	266.1	27	0.39	64.0	97.0	120.8	151.8	161.6	119.0	112.4	4.0	8.0	390	2.26			6
15550	1027	82.3	266.1	89	0.295	58.0	105.8	136.8	194.5	188.3	131.4	126.7	5.0	10.0	505	2.92			

[illegible] 1349 8/5 (12/63) PRECEEDING PAGE NO. ____ FOLLOWING PAGE NO. ____ A.F. SIG. ____ NO: 19941-F


6
OUTPUT VOLTs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT
EXCITOR CURRENT
PARALLEL SYSTEM:
REF. DATA SHEET 1994I- F
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.
OUTPUT AMPs
SYS
1/3 LOAD (27AMPs)

5.7 Parallel Shutdown

Purpose: The purpose of this test was to verify the capability of system protection to properly operate in the event of shutdown of one system during parallel operation.

Procedure and Results: Two systems (I and II) were operated in parallel at 16,000 rpm with rated load (167 amperes) until temperatures stabilized. The load was reduced to 100 amperes and system II shutdown. Data was recorded on LAPEC data sheet 20899 and charts 20899-A and 20899-B. The two systems were again connected in parallel at no load and system II was shutdown. Data was recorded on LAPEC data sheet 20899 and charts 20899-C and 20899-D.

Discussion of Results: The test results show that upon shutdown of system II, system I assumed the total load as required.

L' 'S AEROSPACE
PC EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM I + II SERIAL NO. GEN KL4 121, GCU 10V 126, CURRENT SENSORS 121 136 / 123 238 COG. ENGR. L. HARMAT

ROTOR NO. STATOR NO.

DATE OF TEST 12/21/88 TEST LETTER: NO. TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4-14 PARALLEL SHUTDOWN. PAGE OF

BASA. NO.	TIME	AMB. TEMP.	OUT	PUT	EXCITOR		OIL		STATOR				OIL PRESSURE		OIL	GAL
RPM		GEN	VOLT	AMP	AMP	VOLT	IN	OUT	#1	#2	CASE		IN	OUT	CYC	PER
			PER	LOAD												MIN
16150	SYS I	82.5	266.3	87	0.23	43.0	98.4	181.7	218.3	223.4	126.5		8.5	11.5	555	3.36
15950	SYS II	87.5	266.0	86	0.29	53.0	122.2	156.8	234.9	233.5	157.2		6.0	11.0	592	3.42

LOAD REDUCED TO 50 AMP PER SYSTEM AND SYSTEM II SHUTDOWN

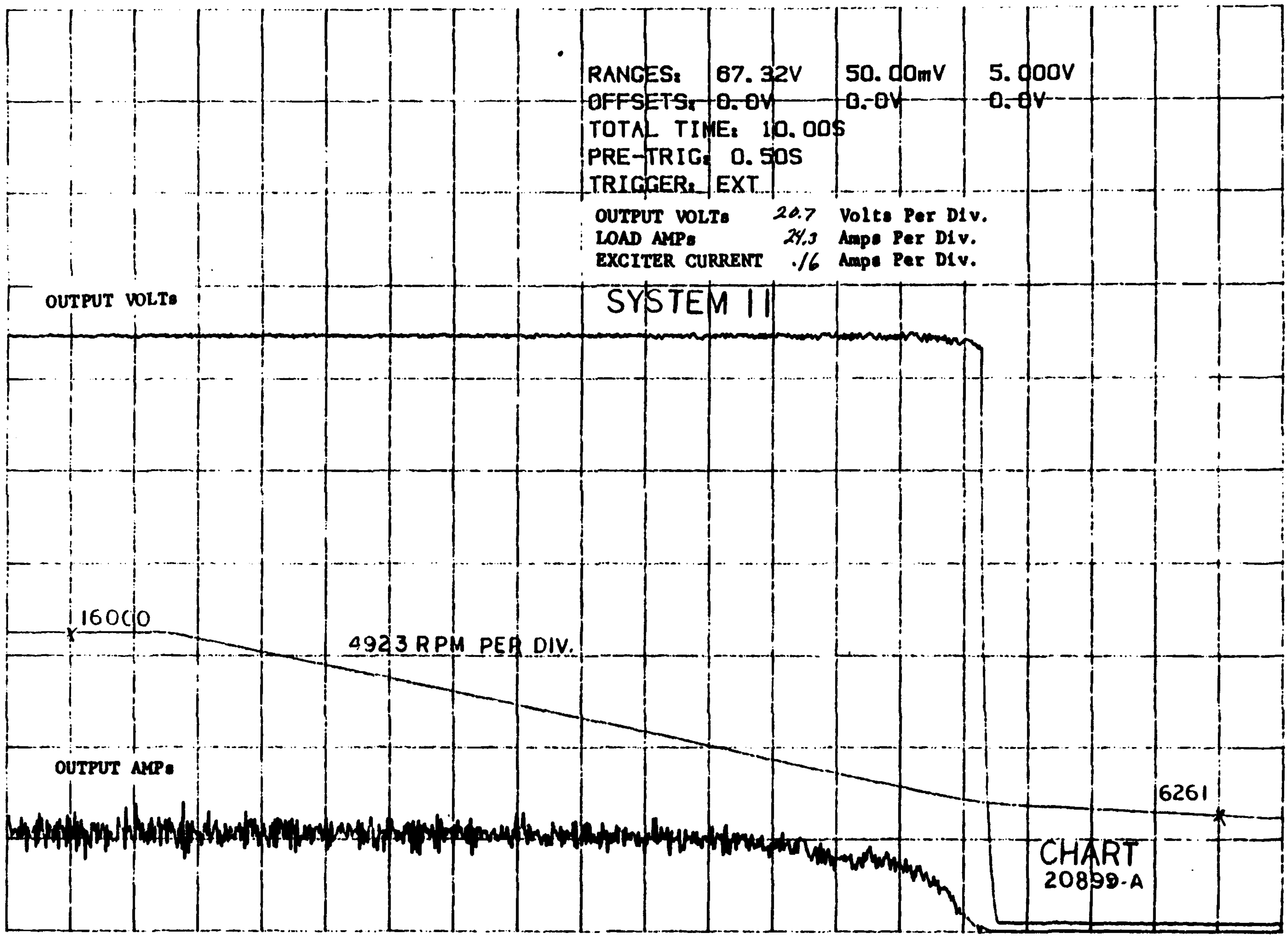
CHART 20899 - A + B ~~SET~~

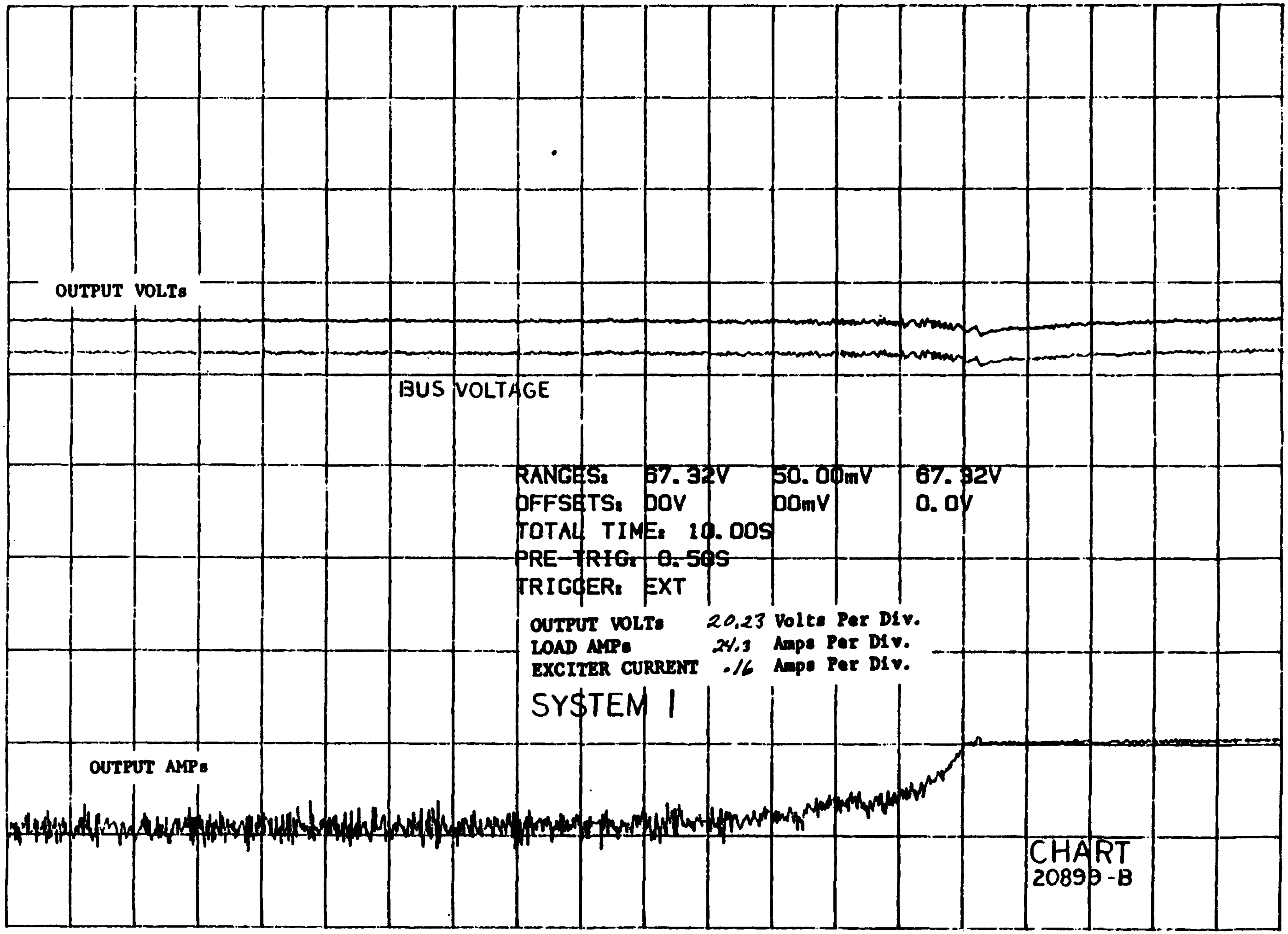
LOAD REDUCED TO "0" PER SYSTEM. (5 AMP PRELOAD EACH)

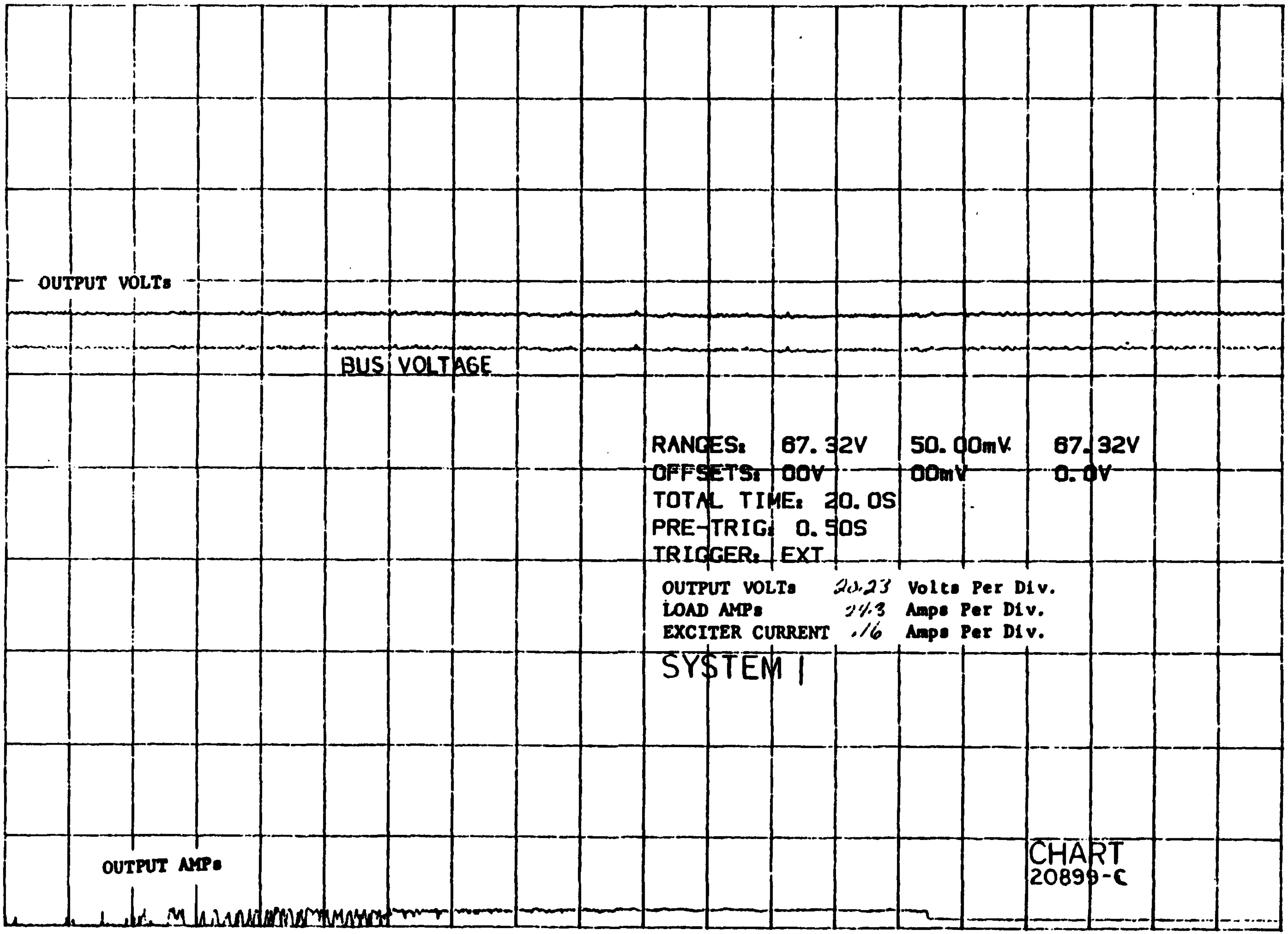
CHART 20899 - C + D

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG.

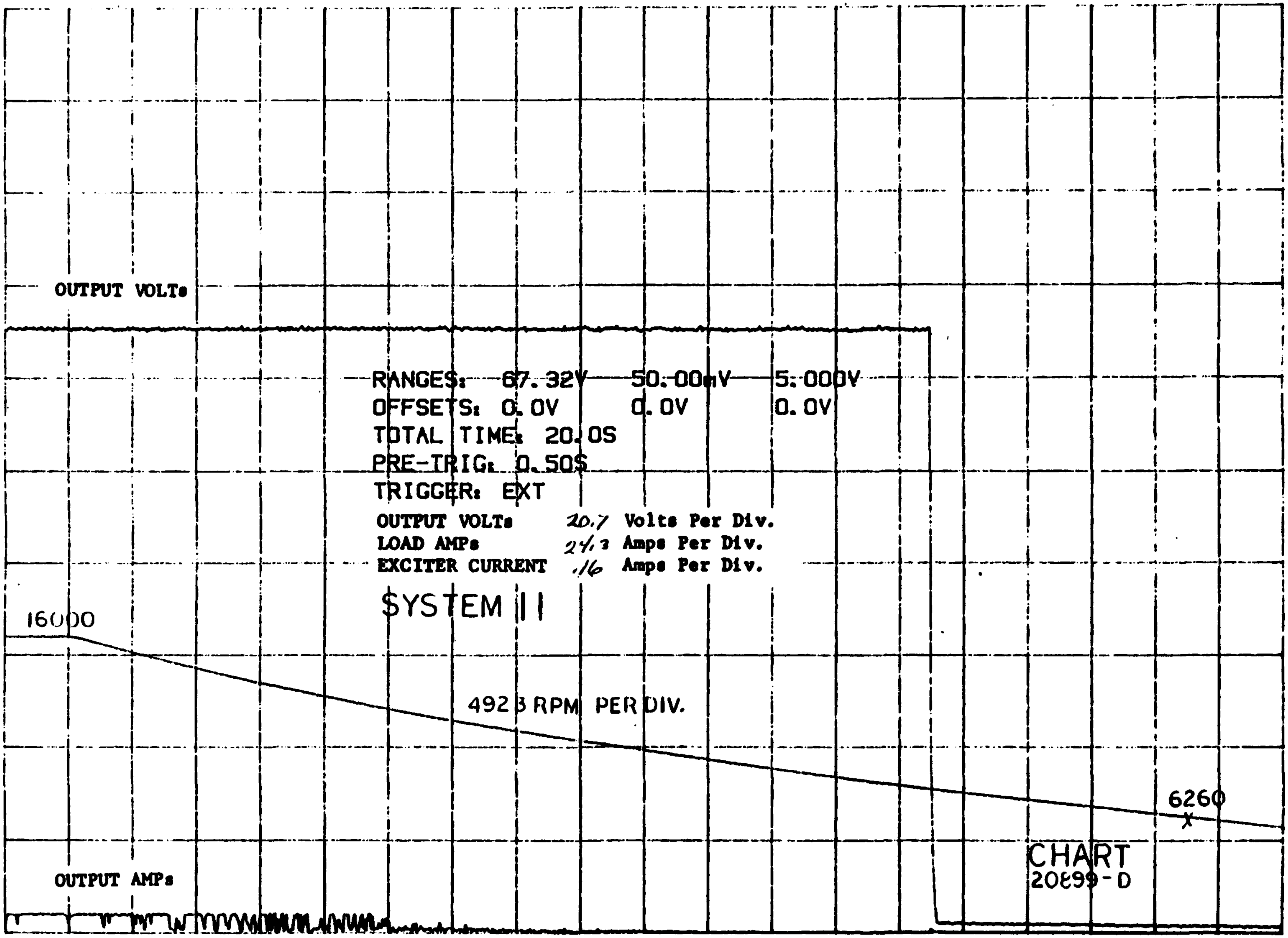
NO: 20899


RANGES: 67.32V 50.00mV 5.000V
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
SYSTEM II
OUTPUT VOLTs
16000
4923 RPM PER DIV.
OUTPUT AMPs
6261
CHART
20899-A


OUTPUT VOLTs
BUS VOLTAGE
RANGES: 67.32V 50.00mV 67.32V
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
SYSTEM I
OUTPUT AMPs
CHART
20899-B



OUTPUT VOLTs
BUS VOLTAGE
RANGES: 67.32V 50.00mV 67.32V
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 20.0S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
SYSTEM I
OUTPUT AMPs
CHART
20899-C


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 5.000V
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 20.0S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
SYSTEM II
16000
4923 RPM PER DIV.
6260
CHART
20899-D
OUTPUT AMPs

5.8 Parallel Load Division

Purpose: The purpose of these tests was to demonstrate that two parallel systems shared load within 10% of a single channel rating with voltage maintained within specification regulation limits.

Procedure: Two distinct tests were performed. Prior to each of these tests, the paralleled systems were operated at rated load on each system (334 amperes total) and the generator speeds at 16,000 rpm. The following tests were performed:

1. The two parallel systems were operated concurrently at rated load (334 amperes) over the speed range from 9,000 rpm to 18,000 rpm on 1,000 rpm increments.

2. With the two paralleled systems operating at full load, the speed of system I was set at 10,000 rpm and the speed of system II varied from 18,000 rpm to 10,000 rpm in 1,000 rpm increments.

Results: Test results were recorded on data sheets 19942-A, 19942-B, 19942-C, 19942-D.

Discussion of Results: The test data indicates, that the two parallel system shared load within 3 amperes (2% of full load rating) when the two generators were operating at the same speeds and when one generator speed was varied with one other held constant, the maximum load sharing differential current did not exceed 6 amperes (4% of full load rating)

L... AEROSPACE
POWER E... P. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMA, / DECLIK

E.W.O. 54805 MODEL NO. SYSTEM 1 SERIAL NO. GCU 104 / CURRENT 121; GEN XLY / SW SAFS 136 ROTOR NO. STATOR NO.

DATE OF TEST 7/22/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.11 A-1 PARALLEL LOAD DIVISION PAGE OF

PARAM. MA. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16000	1306	93.8	269.5	167	0.41	80.0	96.5	132.5	297.5	308.5	120.8	114.5	9.0	15.0	555	3.2	2.5	3.8	
18000	1311	94.7	269.[illegible]	167	0.40	80.0	103.2	145.5	360.5	378.8	132.3	123.7	10.0	15.0	585	3.39	2.2	3.0	
17050	1314	95.6	268.2	167	0.40	81.5	104.8	149.2	378.6	389.6	136.7	127.1	9.8	15.0	580	3.39	3.0	4.0	
16050	1316	95.9	268.8	167	0.41	83.0	104.7	148.9	384.1	394.6	137.2	127.2	9.0	14.5	565	3.27	2.1	3.0	
15050	1319	96.6	268.7	167	0.429	84.5	103.2	147.4	386.3	396.8	136.2	125.8	8.5	14.2	555	3.2	2.1	3.4	
14030	1322	96.8	268.5	166	0.46	87.0	101.8	144.7	385.4	394.8	134.6	124.1	8.0	14.0	530	3.07	2.1	3.2	
13050	1225	97.5	268.5	167	0.49	99.0	100.2	142.9	384.5	394.1	133.9	123.5	8.0	13.9	510	2.95	2.1	4.0	
12050	1329	97.7	268.3	167	0.52	103.5	98.7	141.7	384.4	394.8	132.5	121.7	8.0	13.0	475	2.75	2.2	4.0	
11050	1331	98.4	267.9	167	0.60	119.0	97.4	141.5	386.4	397.8	133.1	122.4	8.0	12.5	440	2.55	2.5	4.0	
10000	1333	98.5	267.2	167	0.68	142.0	95.4	141.6	391.7	404.5	132.8	121.4	10.0	14.0	390	2.26	3.0	4.0	
9050	1335	98.7	262.2	170	0.96	212.4	93.7	143.8	406.7	421.3	133.6	121.2	12.0	15.0	345	1.99	3.5	4.2	
16000	1338	98.9	268.7	168	0.43	88	105.5	151.1	406.4	417.5	139.2	127.5	14.0	21.5	560	3.24	2.0	2.5	

FORM 1349 8/5 (12/63) PRECEEDING PAGE NO. ____ FOLLOWING PAGE NO. ____ A F SIG ____

NO. 19942-A

LUCAS AEROSPACE
POWER EQ. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 11 SERIAL NO. GCU 103 / CURRENT 123; GEN 101 / SENSARS 116 COG. ENGR. HARMAN, DEELIK

ROTOR NO. STATOR NO.

DATE OF TEST 7/22/88 TEST LETTER NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.11 A-1 PARALLEL LOAD DIVISION

PAGE OF

PARM. NO. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16000	1306	93.8	268.9	168	0.465	85.0	118.1	156.6	316.0	301.1	153.7	141.9	6.0	10.5	570	3.45			
18000	1311	94.7	268.5	167	0.42	84.0	130.5	175.7	384.5	374.6	169.2	156.5	5.5	11.0	615	3.72			
17000	1314	95.6	268.8	168	0.43	86.5	135.7	182.8	405.6	396.5	175.5	162.8	5.5	11.0	610	3.69			
16000	1316	95.9	268.5	167	0.432	88.0	136.1	182.6	411.5	403.7	174.8	162.2	5.5	10.0	590	3.57			
15000	1319	96.6	268.4	167	0.44	99.0	134.1	179.8	412.0	405.6	173.4	160.3	5.0	9.6	585	3.54			
14000	1322	96.8	268.2	167	0.50	102.5	132.0	176.5	410.7	405.0	173.0	158.6	5.0	9.5	570	3.45			
13050	1325	97.5	268.1	168	0.54	110.5	130.1	173.1	409.8	404.2	174.1	153.3	5.0	9.0	550	3.33			
12000	1329	97.7	268.0	167	0.59	120	127.9	170.5	408.9	404.0	169.9	153.0	5.0	8.5	530	3.21			
11050	1331	98.4	267.4	167	0.63	134	126.6	169.1	408.9	404.3	169.0	149.1	5.0	8.5	500	3.03			
10000	1333	98.5	266.8	167	0.78	166	125.2	167.3	409.4	405.0	167.4	150.3	5.0	8.5	450	2.73			
9100	1335	98.7	262.1	167	1.0	218	124.6	166.0	405.4	403.8	166.4	150.7	5.0	8.5	460	2.79			
16000	1338	98.9	268.3	168	0.47	97.5	132.7	178.2	410.8	403.3	172.5	152.4	14.0	18.0	590	3.57			

FORM 1349 8/5 (12/63) PRECEEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG.

NO. 19912-D

LUCAS AEROSPACE
POWER EDI .CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 1 SERIAL NO. GCU 104 / CURRENT 121 GEN XL4 / SENSORS 126 COG. ENGR. HARMAIJ/DERLIK

ROTOR NO. STATOR NO.

DATE OF TEST 7/23/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.11 A-2 PARALLEL LOAD DIVISION

PAGE OF

RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16100	1509	99.5	269.4	167	0.41	78.0	99.4	134.8	314.1	325.0	123.9	119.2	9.0	14.5	555	3.21	2.5	4.0	
16000	1521	100.2	268.8	167	0.3	56.0	100.0	135.1	259.2	264.8	125.1	120.5	12.5	23.5	560	3.18	2.1	3.0	
16000	1526	102.2	268.8	167	0.3	57.0	101.0	136.5	264.8	270.2	128.2	122.8	17.5	22.5	545	3.16	2.1	3.0	
10000	1528	102.3	268.5	165	0.46	86.5	94.8	130.8	263.6	270.8	124.8	118.0	15.0	19.0	390	2.26	2.2	4.0	
9950	1530	102.6	268.6	165	0.46	86.0	94.1	129.0	263.4	270.6	123.2	116.1	15.0	19.0	390	2.26	2.4	3.8	
10000	1532	102.7	268.4	165	0.465	86.0	94.0	128.7	263.3	270.5	123.0	116.1	15.0	19.0	390	2.26	2.4	3.8	
10000	1534	103.2	268.4	165	0.46	86.0	94.1	128.5	263.5	270.5	123.2	116.1	15.2	19.2	395	2.29	2.4	4.0	
10000	1537	103.6	268.3	165	0.465	86.0	94.2	128.4	263.7	270.7	123.1	116.0	15.4	19.0	395	2.29	3.0	3.8	
9950	1539	103.8	268.2	165	0.47	86.0	93.9	128.5	263.6	271.0	123.0	115.9	15.2	19.2	395	2.29	3.0	4.0	
10000	1541	103.8	268.1	165	0.47	86.4	93.9	128.6	264.0	272.0	123.8	116.4	15.0	19.2	395	2.29	3.0	4.0	
10000	1544	104.7	268.0	166	0.48	87.0	93.9	128.6	264.6	272.2	123.8	116.4	15.0	19.2	385	2.29	3.0	4.0	
10000	1547	104.7	267.8	167	0.475	87.0	94.1	128.7	266.4	274.1	123.7	116.5	15.0	19.2	395	2.29	3.2	4.0	
16000	1550	105.0	268.8	167	0.30	67.0	99.4	134.7	265.5	272.1	127.0	120.6	17.0	23.0	560	3.18	2.0	2.5	

LUCAS AEROSPACE
POWER EQU'' .CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEM 11 SERIAL NO. GCU 103 / CURRENT 123; GEN 101 / SENSORS 326 COG. ENGR. HARMAI, JERLIK

ROTOR NO. STATOR NO.

DATE OF TEST 7/23/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.11 A-2 PARALLEL LOAD DIVISION PAGE OF

PARAL. RPM	TIME	AMB. TEMP. GEN	OUTPUT VOLT P.O.R.	OUTPUT AMP LOAD	EXCITER AMP	EXCITER VOLT.	OIL IN	OIL OUT	STATOR #1	STATOR #2	CASE	GEAR BOX	OIL PRESSURE IN	OIL PRESSURE OUT	OIL CYCLES	GAL PER MIN	RIPPLE +	RIPPLE −	CHART NO.
16050	1509	99.5	268.0	167	0.45	53	121.3	159.8	338.7	321.8	159.1	141.3	5.0	10.0	565	3.42			
16000	1521	100.2	268.6	165	0.37	68	121.6	158.7	276.6	272.4	157.1	144.0	5.0	9.5	555	3.36			
16000	1526	102.2	268.5	169	0.37	69	124.9	164.0	287.4	284.0	160.7	147.4	5.0	9.5	560	3.33			
18000	1528	102.3	268.2	171	0.35	66.5	129.0	170.4	294.3	289.9	165.3	152.9	5.0	10.0	594	3.6			
17050	1530	102.6	268.1	171	0.36	69	130.1	171.5	298.7	294.9	162.0	154.2	5.0	10.0	595	3.6			
15950	1532	102.7	268.1	171	0.37	72.0	129.3	169.7	299.2	295.9	166.2	[illegible]	5.0	9.5	585	3.54			
15000	1534	103.2	268.1	170	0.385	74.0	127.8	167.4	297.6	294.7	164.3	150.7	5.0	9.5	555	3.36			
14050	1537	103.5	268.0	170	0.40	76.0	125.5	163.4	293.7	291.3	161.4	146.8	4.5	9.5	520	3.21			
13050	1539	103.8	268.0	170	0.425	80.0	123.4	160.2	290.6	288.3	159.0	144.3	4.5	9.5	536	3.21			
11950	1541	103.8	267.8	170	0.465	87.0	121.6	157.8	287.7	285.5	157.6	142.2	4.5	9.0	500	3.03			
11050	1544	104.7	267.6	169	0.52	97.0	119.3	154.3	284.4	282.4	154.7	139.6	4.5	8.5	485	2.94			
10000	1547	104.7	267.4	168	0.6	113	117.0	151.1	281.8	280.4	153.0	137.1	4.5	8.0	465	2.82			
													4		~~565~~				
16000	1550	105.0	268.5	168	0.37	69	121.0	158.2	284.4	281.5	157.2	141.5	5.0	9.5	565	3.42			

FORM 1349 8/5 (12/63) PRECEEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG.

NO. 10042-D

5.9 Overvoltage Function Trip

Purpose: The purpose of this test was to demonstrate the effectiveness of system protection when a fault exists on one channel of a parallel system resulting in overexcitation/overvoltage condition.

Procedure: Two systems, I and II, were operated in parallel at 10,000, 16,000, and 18,000 rpm. At each of these speeds, tests were run at 0, 50, and 100% rated load with faults applied first to system I and then to system II.

Results: Test results are tabulated in Table 5-4. This table corresponds to LAPEC data sheet 20897 and accompanying charts.

Discussion of Results: Test results show correct faulty system isolation under full-load (167 amperes) condition. However, at lighter loads and no load, the sensing of the faulty system is not reliable and can lead to the loss of both systems. Just like in the case of underexcitation, (Ex: Sensing of load and exciter field current) the detection of overexcitation need to be improved to properly identify the faulty system.

TABLE 5-4

OVEREXCITATION/OVERVOLTAGE FUNCTION TRIP

RPM	% Load	Syst. Faulted	Max. Volts Syst. I	Max. Volts Syst. II	Chart No. Syst. I	Chart No. Syst. II
10,000	0	I	353	355	1	1A
10,000	0	II	364	326	A	A1
16,000	0	I	424	432	1B	1C
16,000	0	II	424	433	A2	A3
18,000	0	I	421	433	1D	1E
18,000	0	II	421	433	A4	A5
10,000	50	I	335	338	2	2A
10,000	50	II	353	322	B	B1
16,000	50	I	334	342	2B	2C
16,000	50	II	343	349	B2	B3
18,000	50	I	339	347	2D	2E
18,000	50	II	423	433	B4	B5
10,000	100	I	313	313	3	3A
10,000	100	II	320	329	C	C1
16,000	100	I	338	360	3B	3C
16,000	100	II	317	342	C2	C3
18,000	100	I	311	377	3D	3E
18,000	100	II	334	372	C4	C5

AS AEROSPACE
R EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. L. HARMAT

E.W.O. 54805 MODEL NO. SYSTEMS I & II SERIAL NO. GEN 124 / 123, GCU 107 / 108, CURRENT SENSOR 121 / 126 / 133 / 138 ROTOR NO. STATOR NO.

DATE OF TEST 12/23/88 TEST LETTER: NO. QP387 TESTED BY R.J. SANIUK

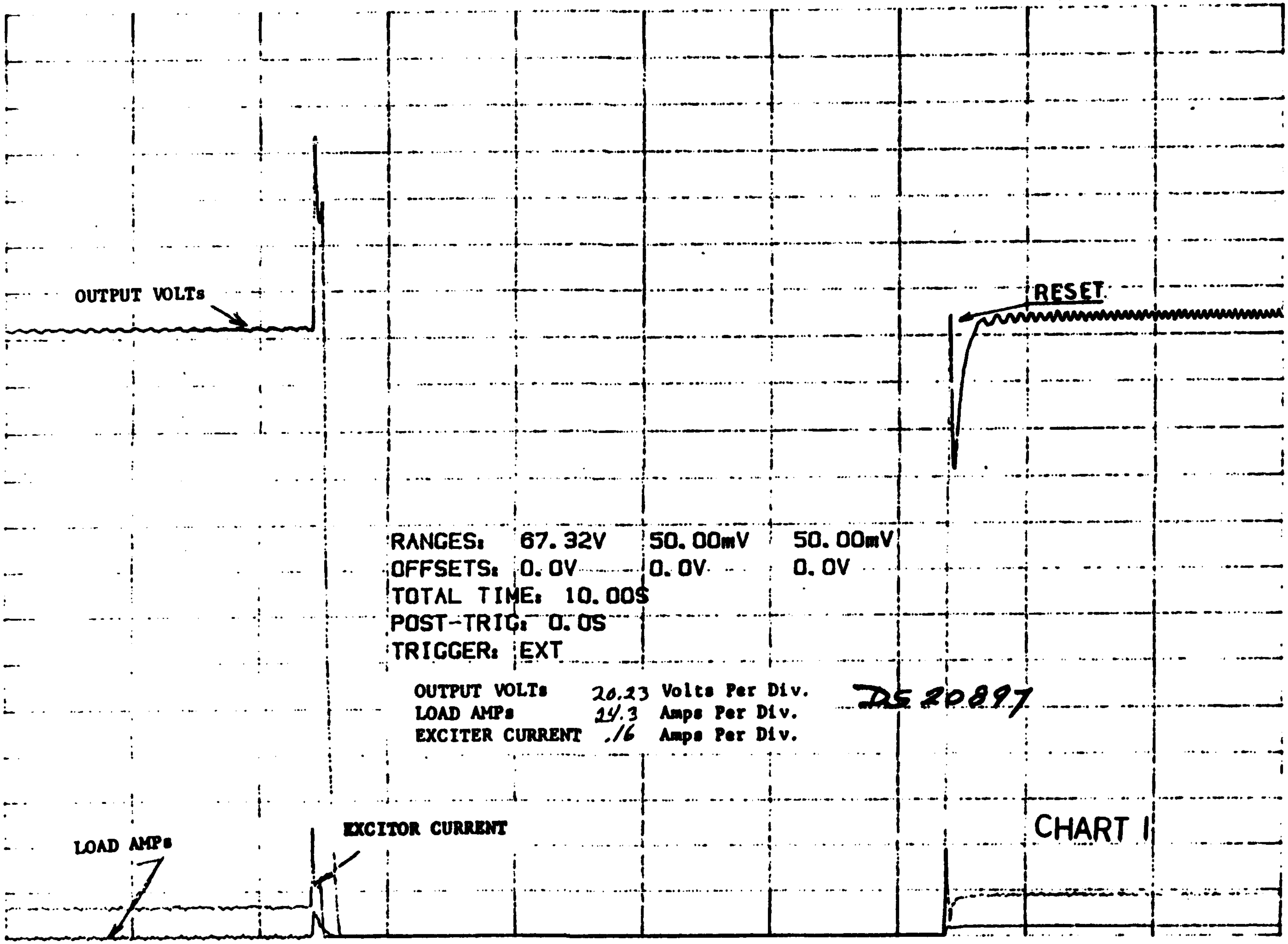
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: 4.12 OVEREXCITATION/OVERVOLTAGE FUNCTION TRIP. PAGE OF

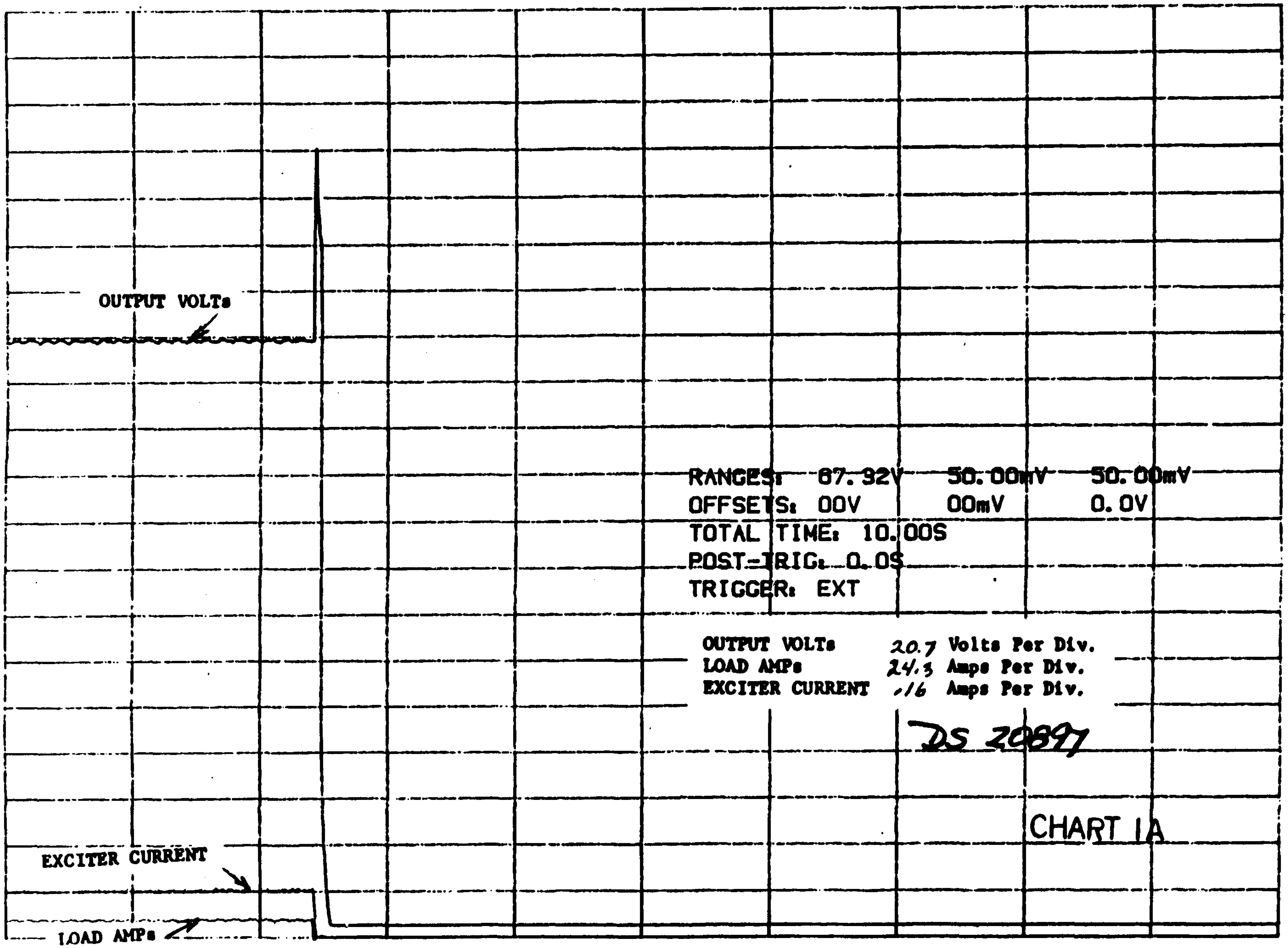
PARA. NO.	TIME	AMB. TEMP.	OUTPUT		EXCITOR			OIL		STATOR					BAL PER			CHART	
RPM			VOLT	AMP	AMP	VOLT		°IN	OUT	#1	#2	CASE			MIN.			NO.	
16000	SYS	I	266.4	84.3	0.23	42.0		100.0	133	216.0	222.0	122.0			3.4			—	
15985	SYS	II	266.3	85.0	0.30	53.0		124.0	159.0	236.0	235.0	155.0			3.4			—	
10000	SYS	I	FAULTED		CHART		1	No Load (0%)					CHART		A	—		SYS	I
10000	SYS	II	—		CHART		1A	No Load		0%			CHART		A1	FAULTED		SYS	II
16000	SYS	I	FAULTED		CHART		1B	No Load		0%			CHART		A2	—		SYS	I
16000	SYS	II	—		CHART		1C	No Load		0%			CHART		A3	FAULTED		SYS	II
18000	SYS	I	FAULTED		CHART		1D	No Load		0%			CHART		A4	—		SYS	I
18000	SYS	II	—		CHART		1E	No Load		0%			CHART		A5	FAULTED		SYS	II
10000	SYS	I	FAULTED		CHART		2	Load	83.5A	50%			CHART		B	—		SYS	I
10000	SYS	II	—		CHART		2A	Load	83.5A	50%			CHART		B1	FAULTED		SYS	II
16000	SYS	I	FAULTED		CHART		2B	Load	83.5A	50%			CHART		B2	—		SYS	I
16000	SYS	II	—		CHART		2C	Load	83.5A	50%			CHART		B3	FAULTED		SYS	II
18000	SYS	I	FAULTED		CHART		2D	Load	83.5A	50%			CHART		B4	—		SYS	I
18000	SYS	II	—		CHART		2F	Load	83.5A	50%			CHART		B5	FAULTED		SYS	II
10000	SYS	I	FAULTED		CHART		3	Load	167A	100%			CHART		C	—		SYS	I
10000	SYS	II	—		CHART		3A	Load	167A	100%			CHART		C1	FAULTED		SYS	II
16000	SYS	I	FAULTED		CHART		3B	Load	167A	100%			CHART		C2	—		SYS	I
16000	SYS	II	—		CHART		3C	Load	167A	100%			CHART		C3	FAULTED		SYS	II
18000	SYS	I	FAULTED		CHART		3D	Load	167A	100%			CHART		C4	—		SYS	I
18000	SYS	II	—		CHART		3E	Load	167A	100%			CHART		C5	FAULTED		SYS	II

PRECEEDING FOLLOWING

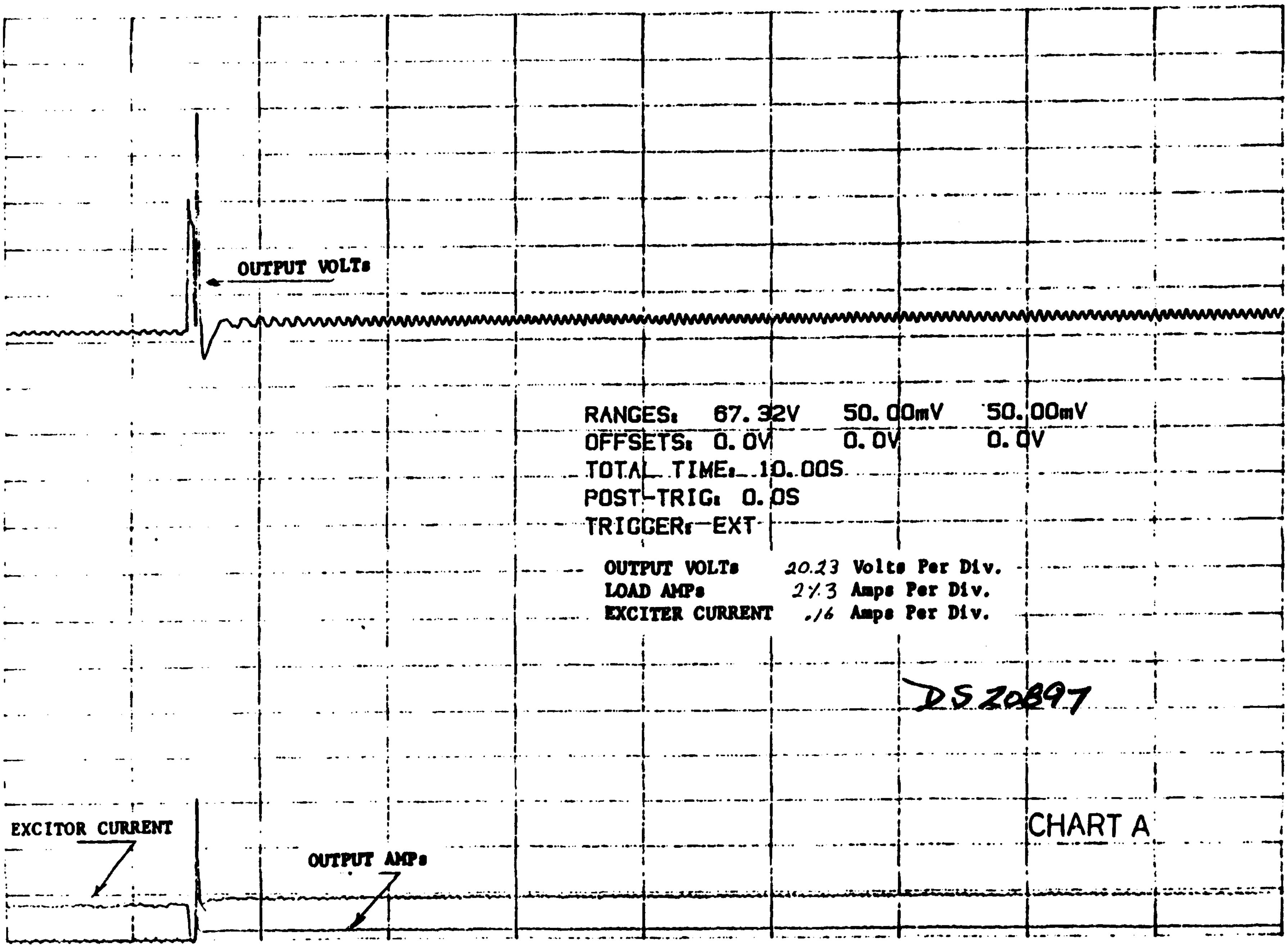
NO. 0000



OUTPUT VOLTs
RESET
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
LOAD AMPs
EXCITOR CURRENT
CHART I

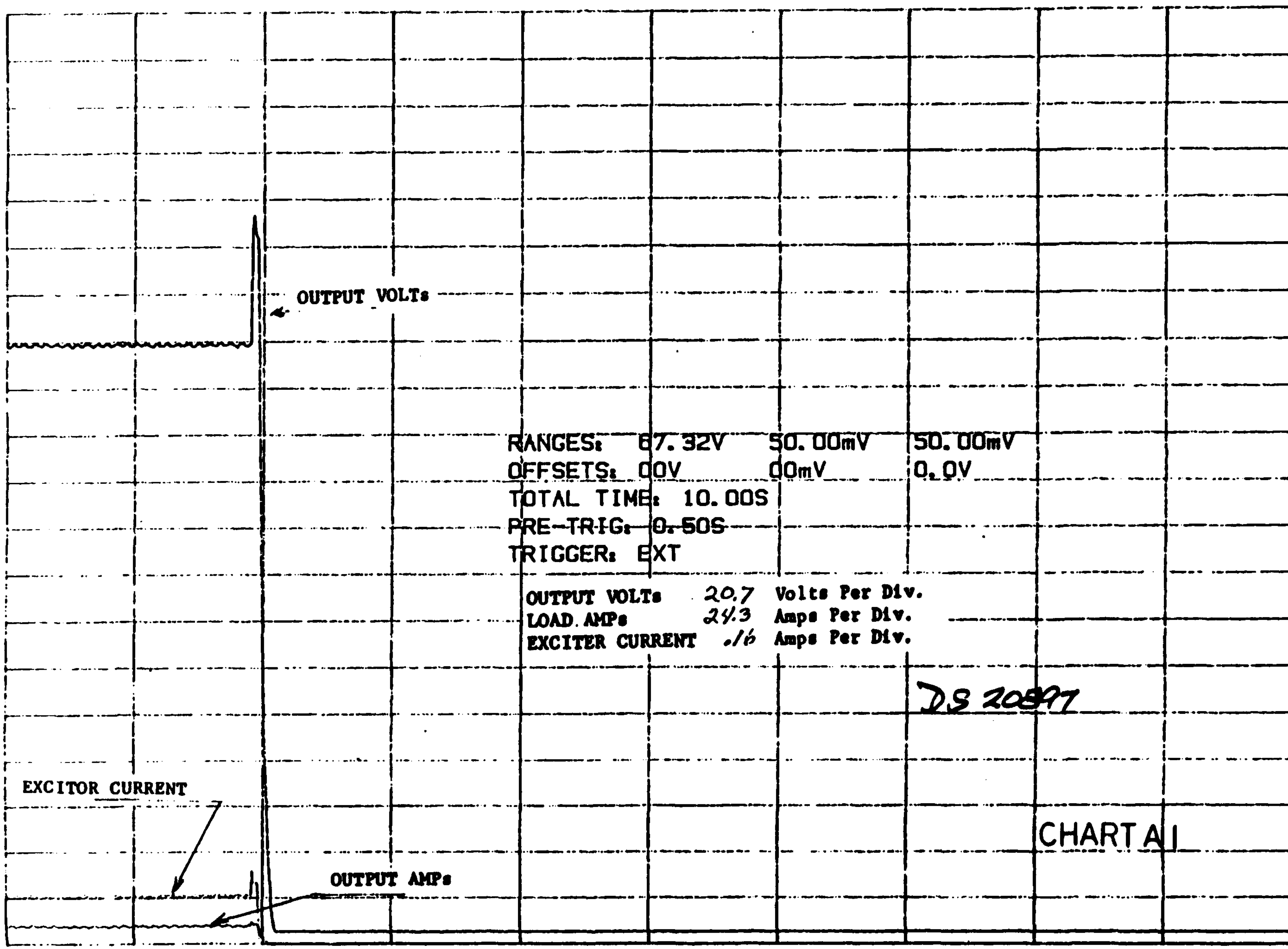


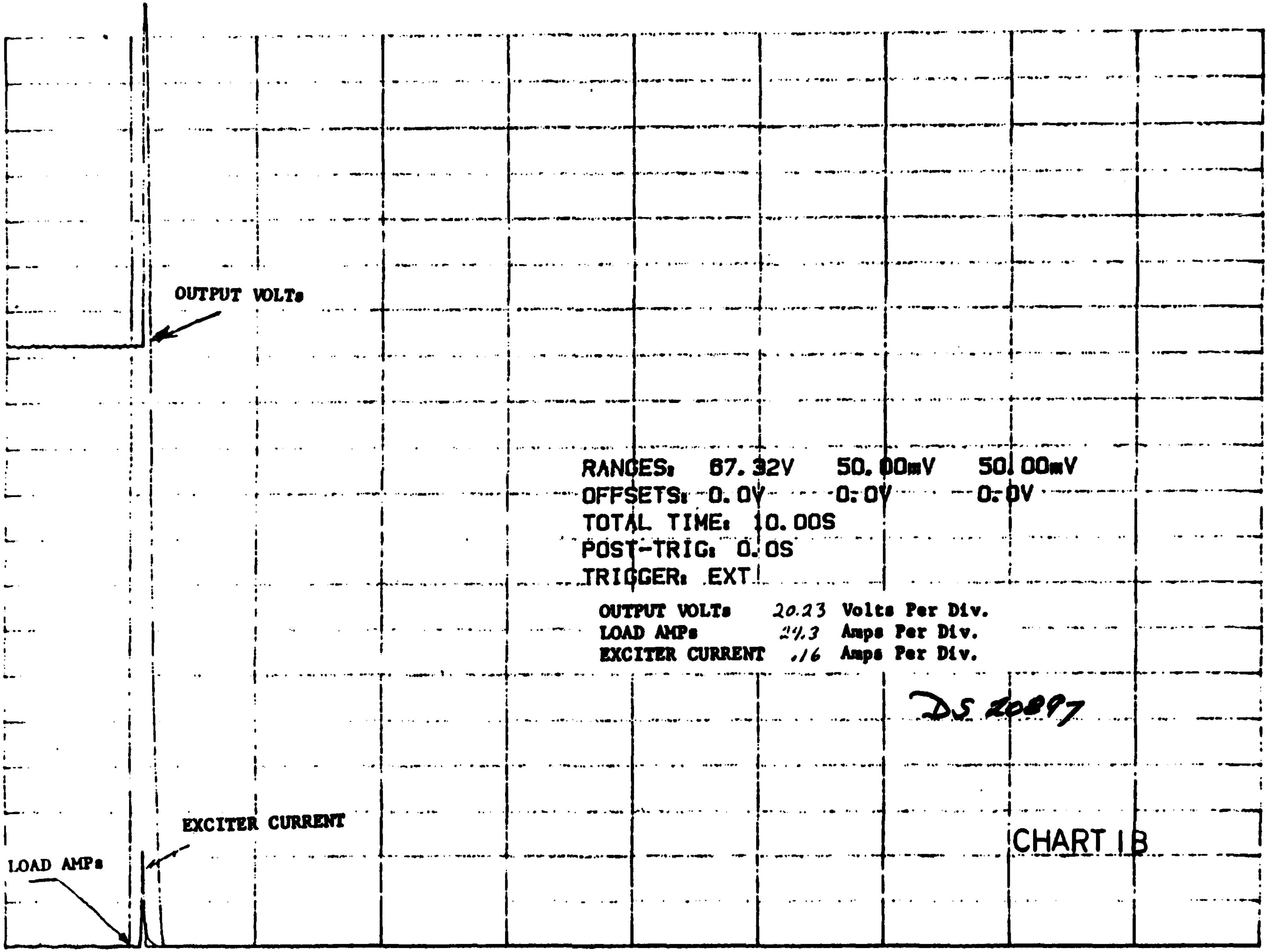
OUTPUT VOLTs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
CHART IA
EXCITER CURRENT
LOAD AMPs



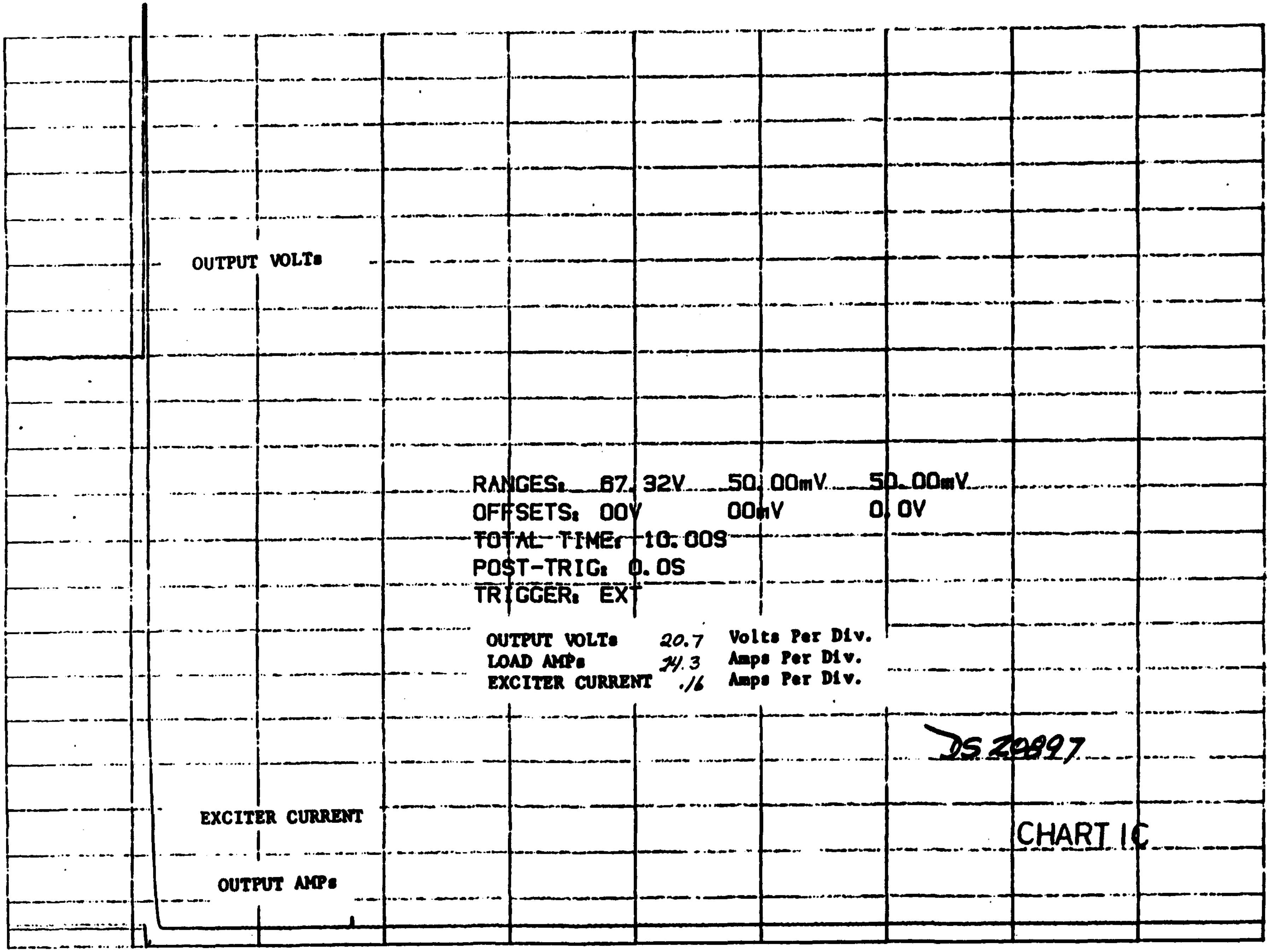
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 2.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
EXCITOR CURRENT
OUTPUT AMPs

CHART A

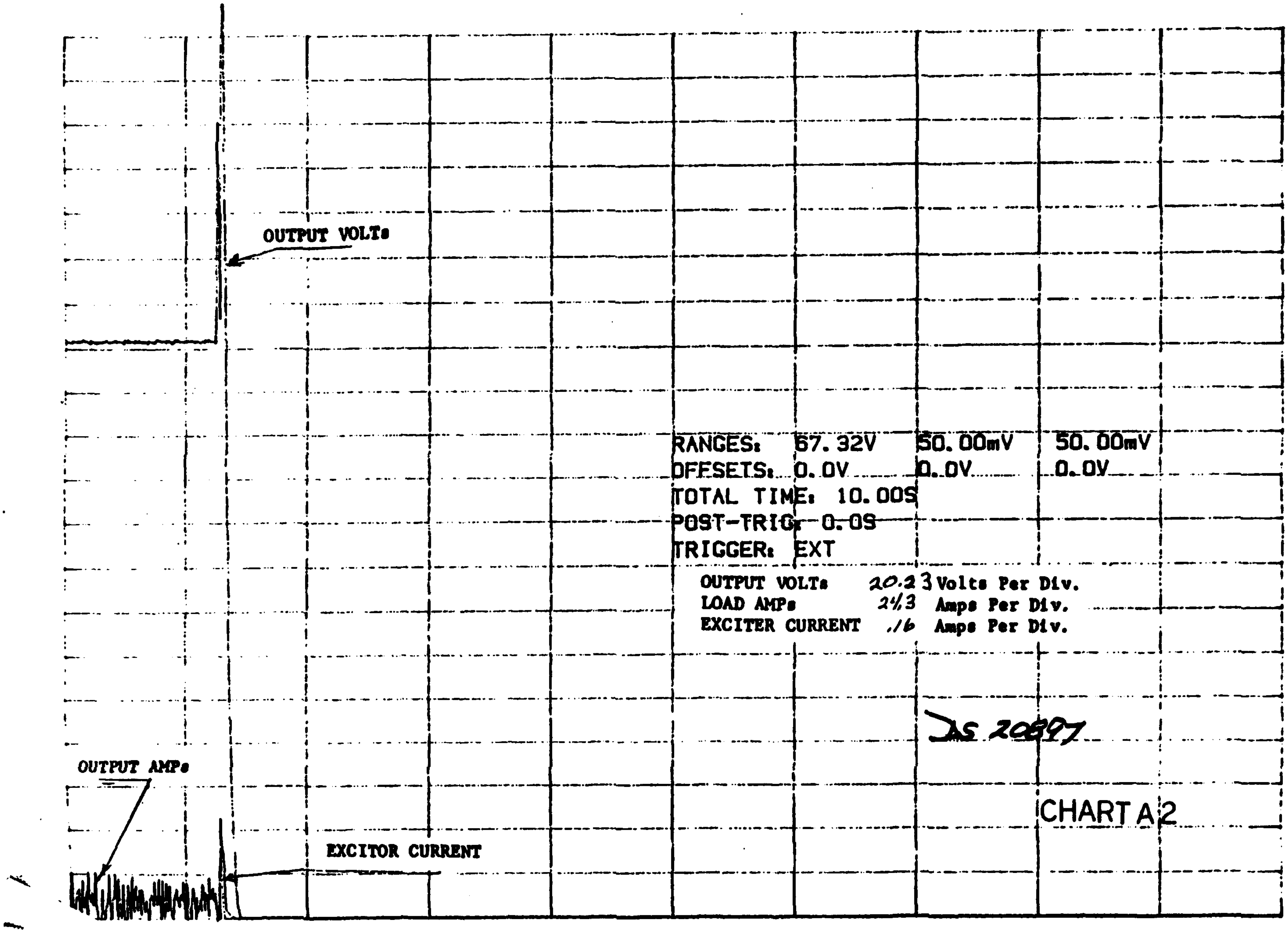

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
EXCITOR CURRENT
OUTPUT AMPs
CHART A1



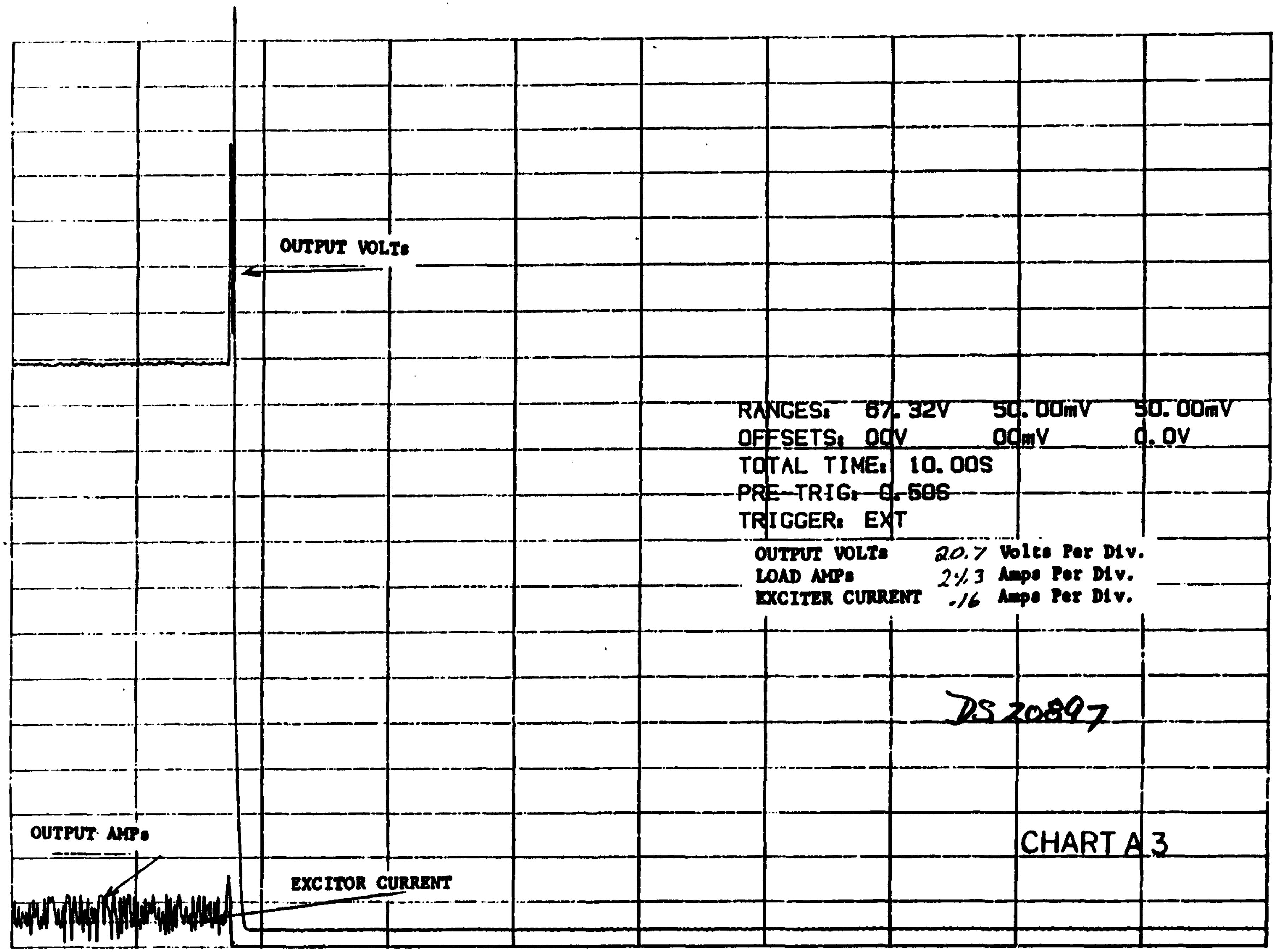
OUTPUT VOLTs
EXCITER CURRENT
LOAD AMPs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
CHART IB



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 29897
EXCITER CURRENT
OUTPUT AMPs
CHART IC

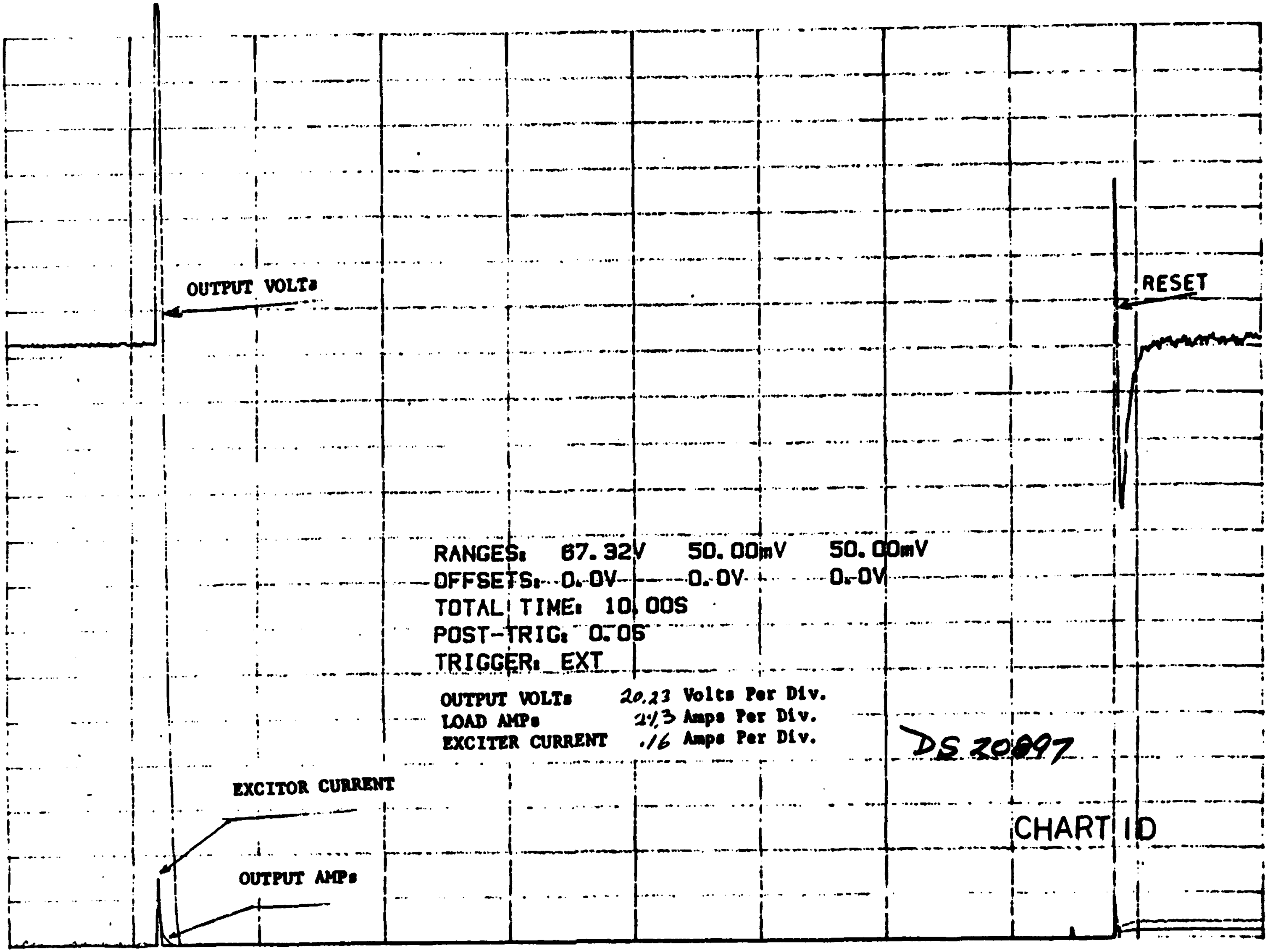


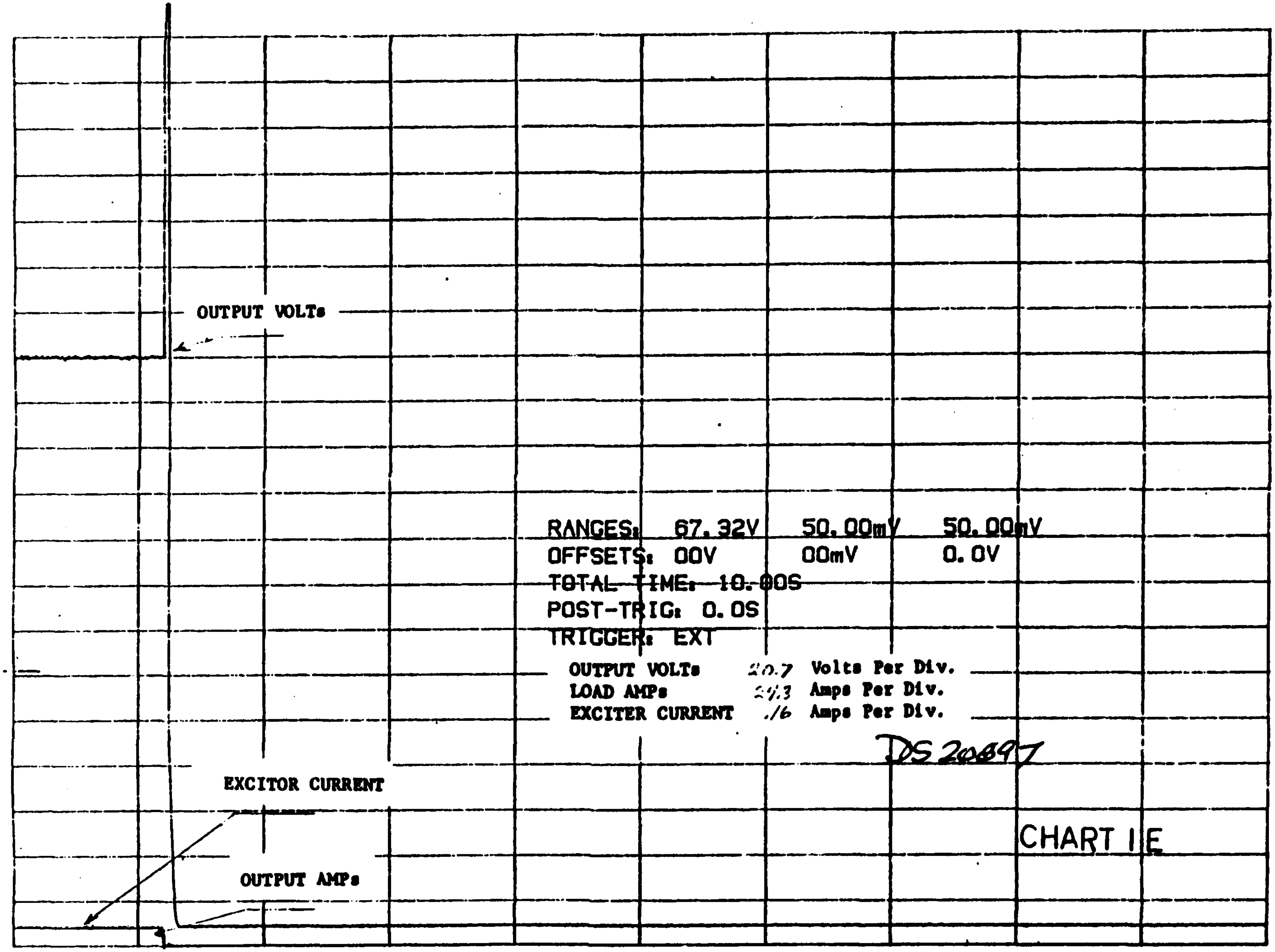
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
CHART A2



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 2½3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
OUTPUT AMPs
EXCITOR CURRENT

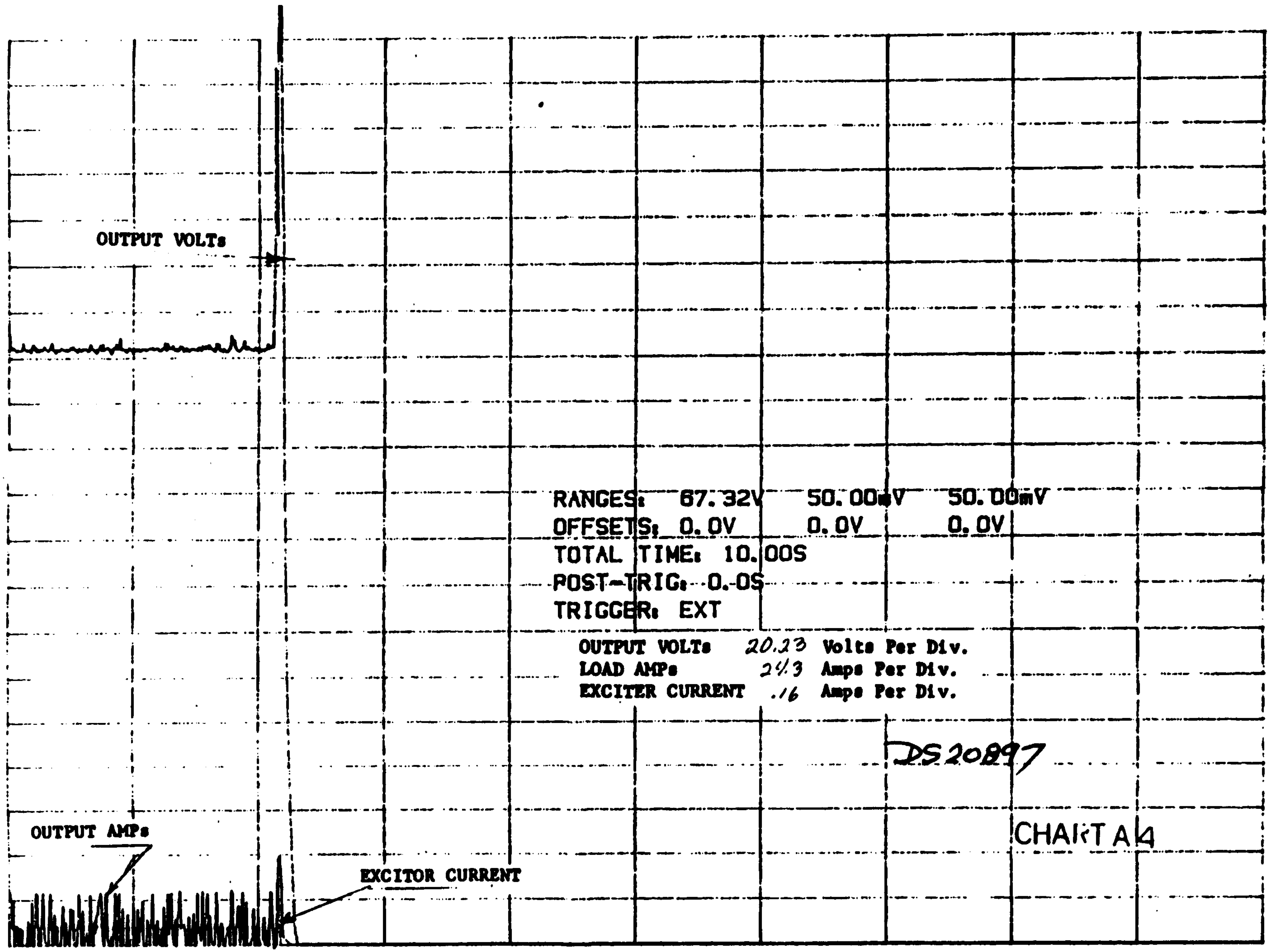
CHART A 3


OUTPUT VOLTs
RESET
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.06
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
EXCITOR CURRENT
OUTPUT AMPs
CHART ID



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
EXCITOR CURRENT
OUTPUT AMPs

CHART I E


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS20897
CHART A4

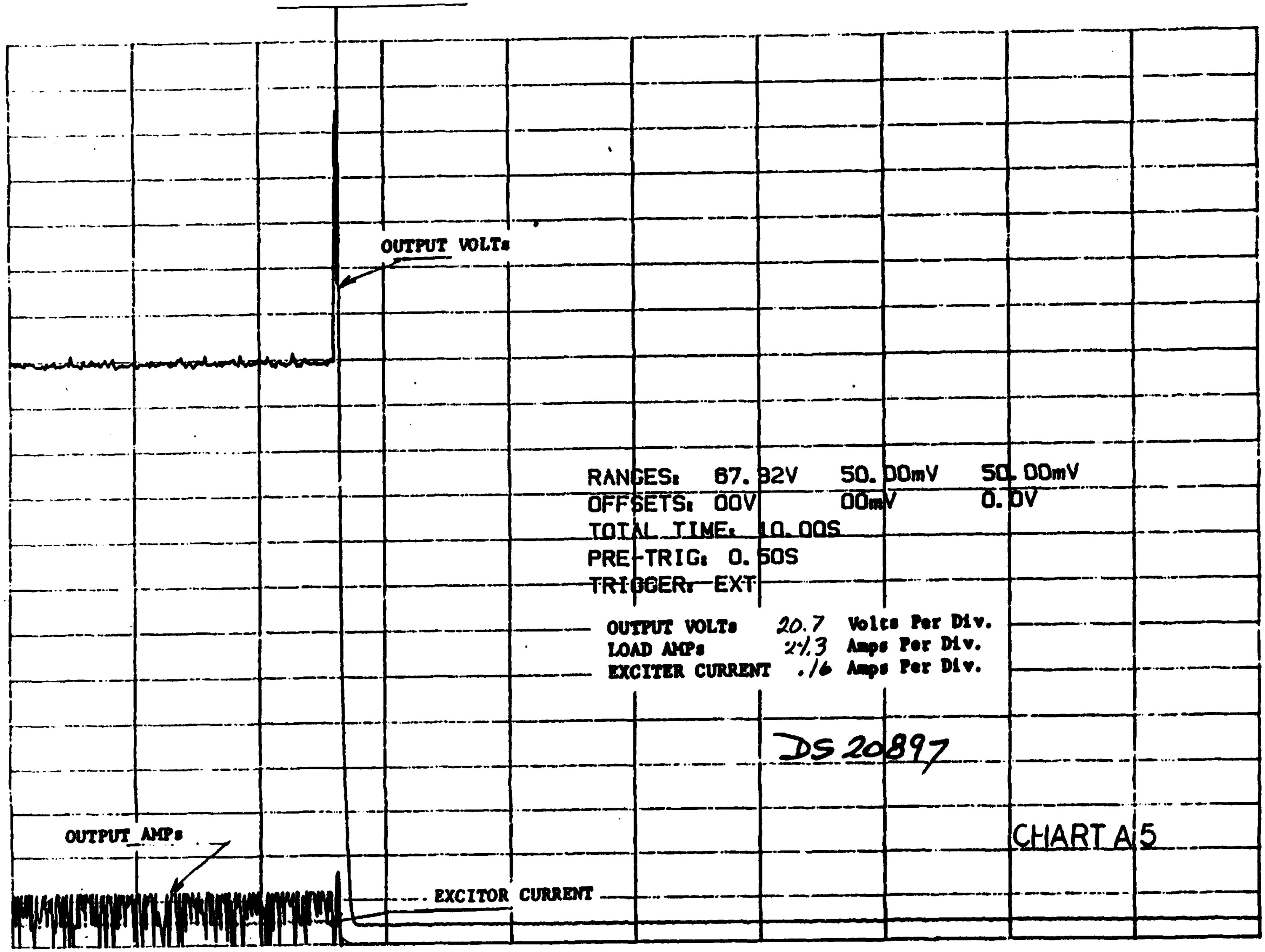
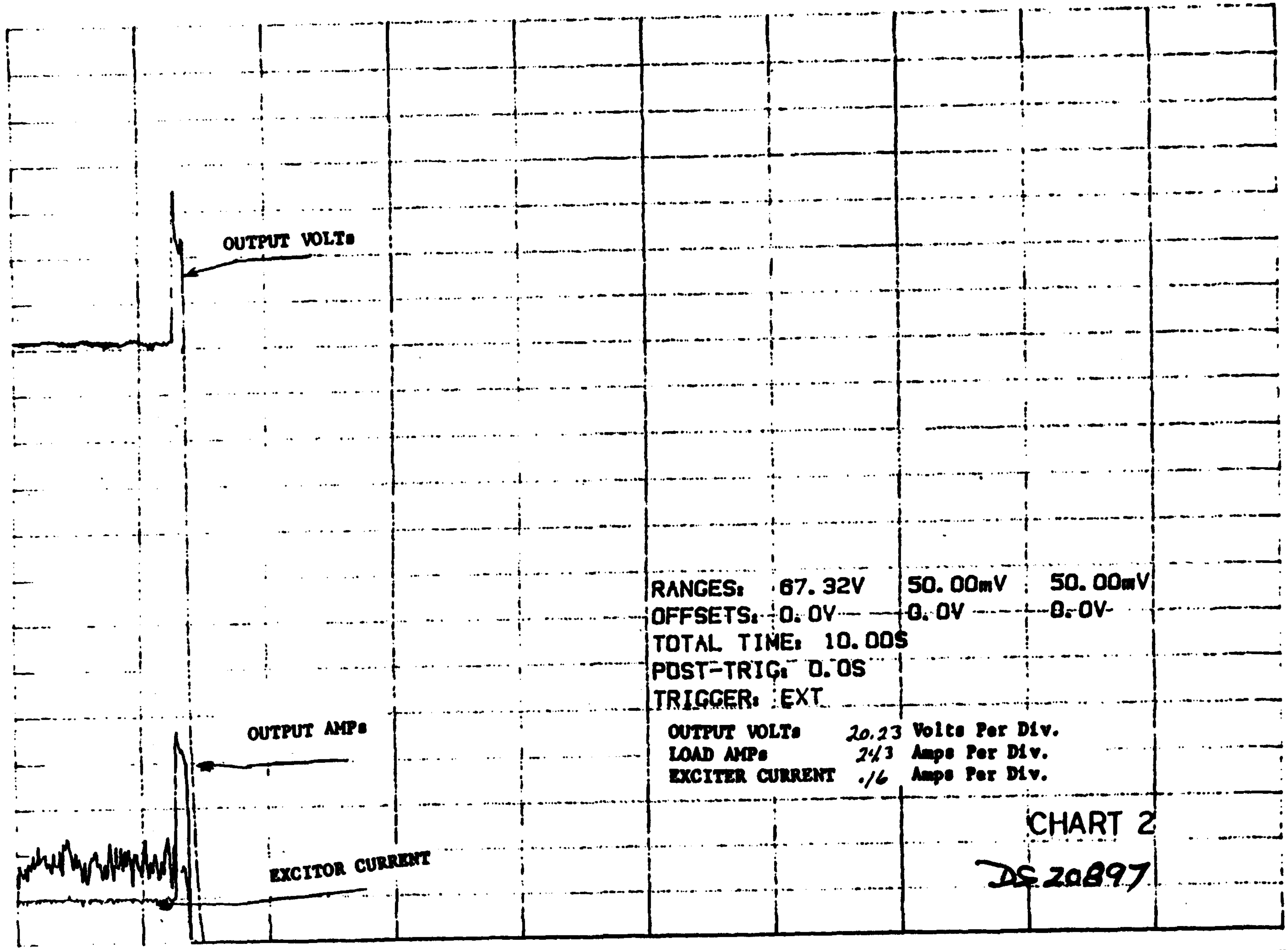
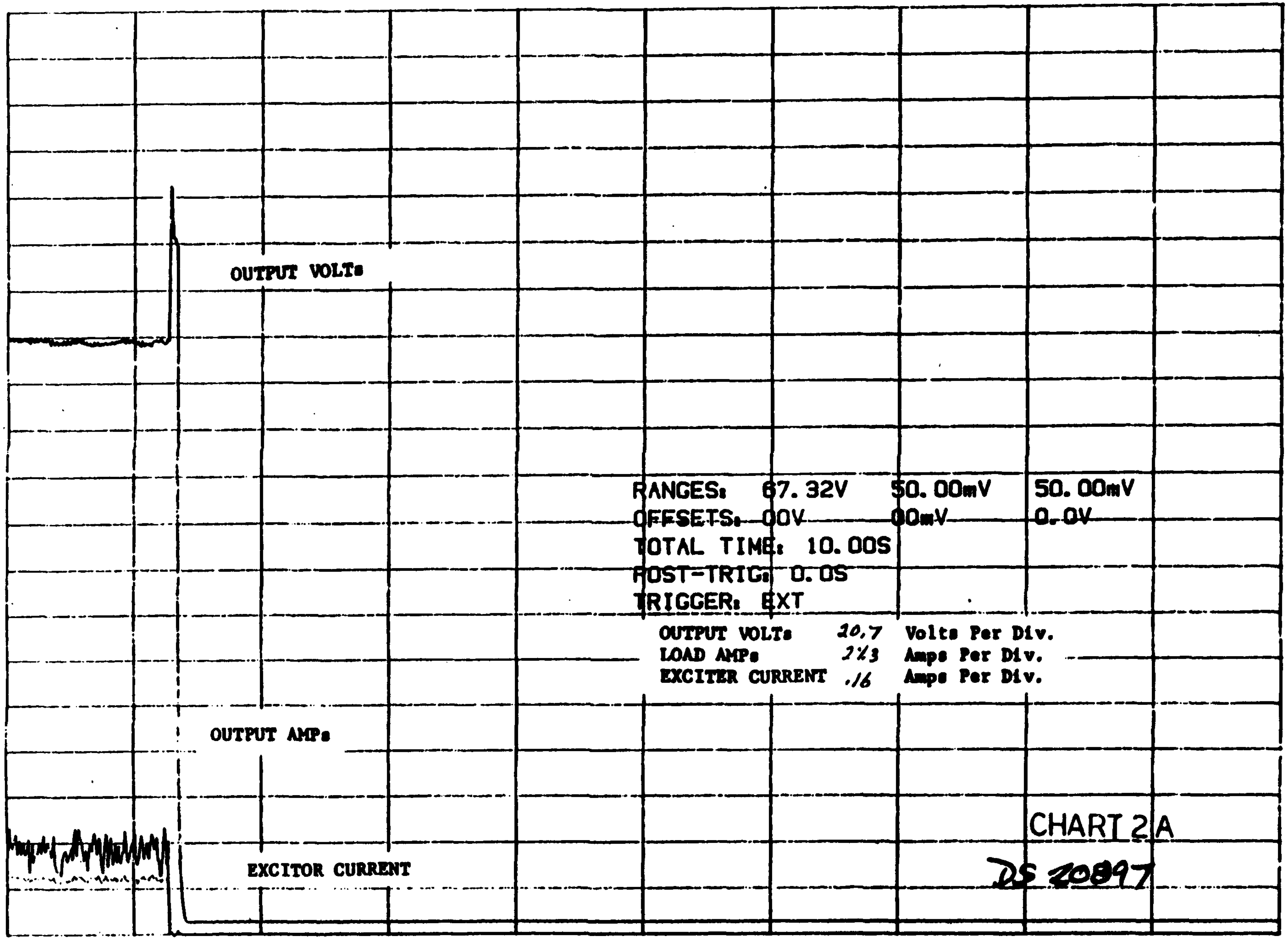
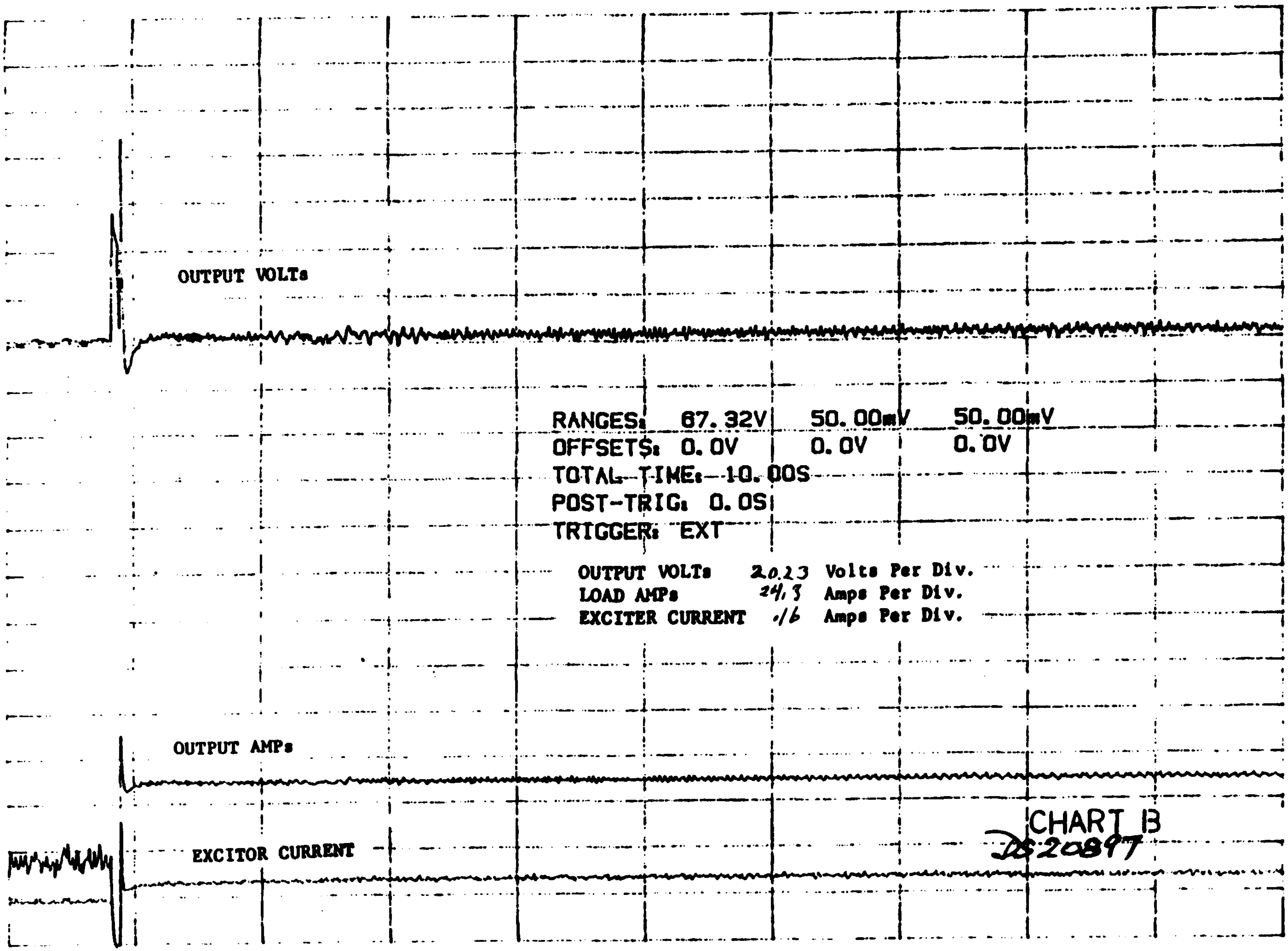

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
DS 20897
OUTPUT AMPs
EXCITOR CURRENT

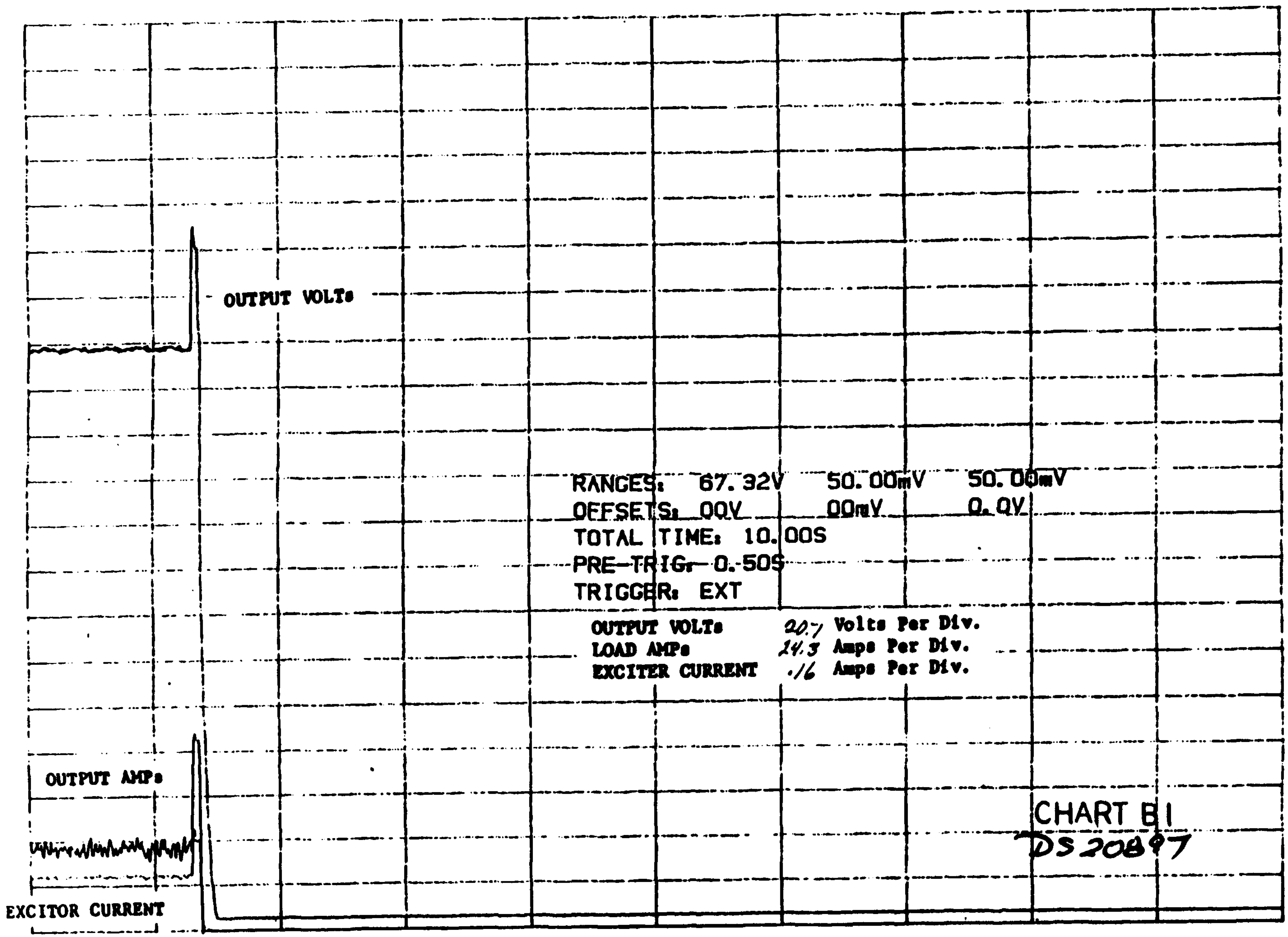
CHART A5

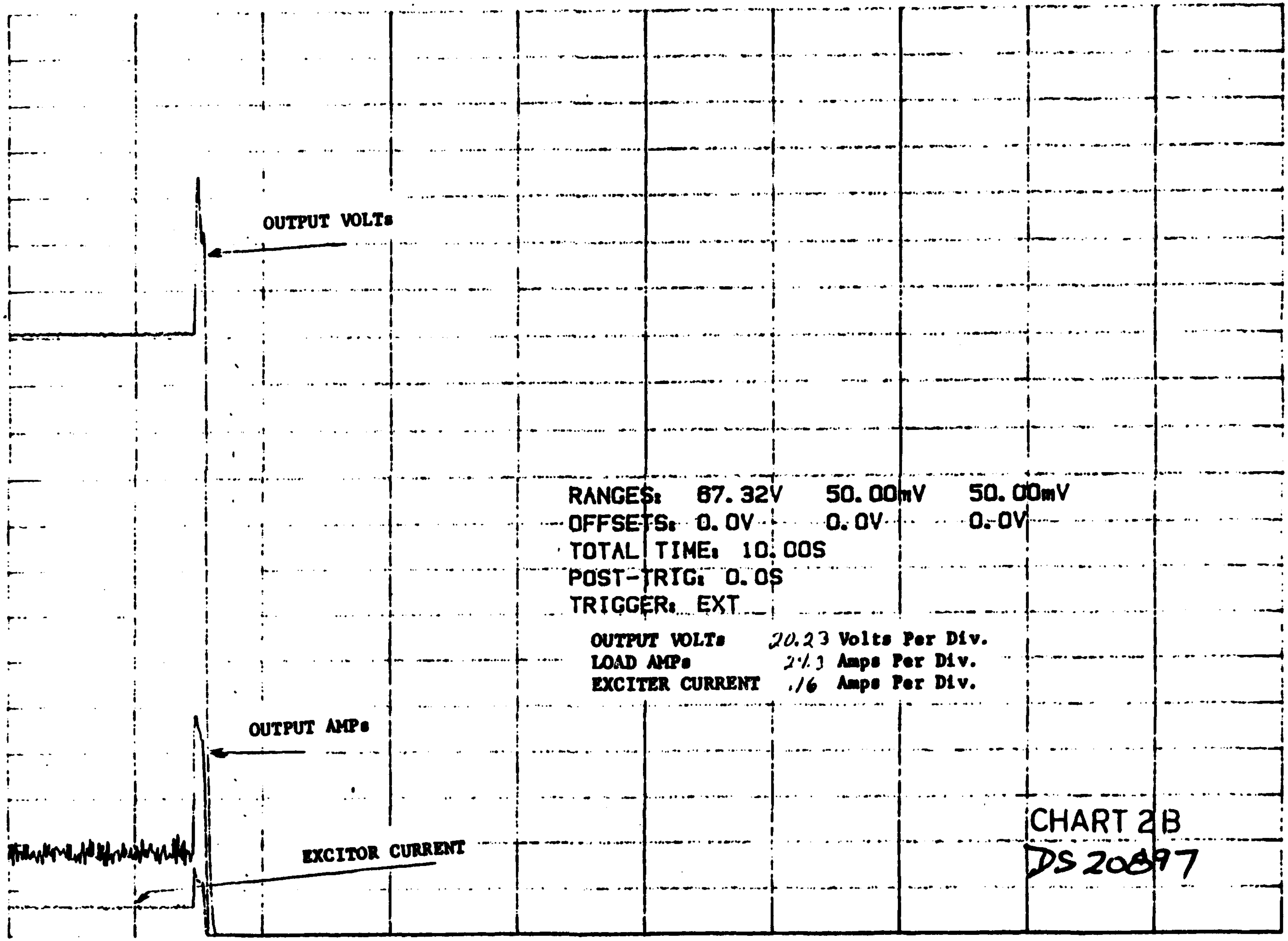

OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 2
DS 20897



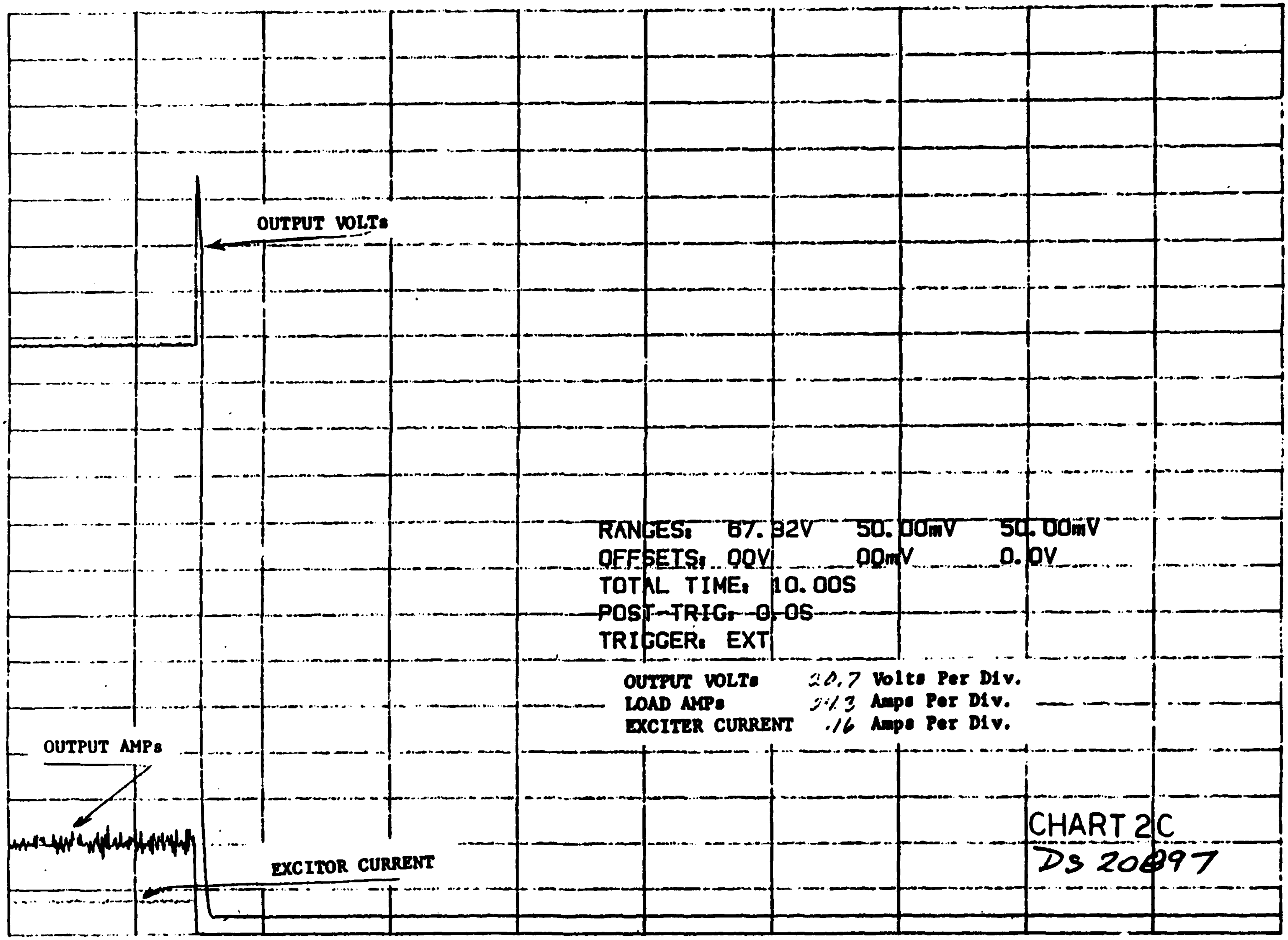
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 2%3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 2A
DS 20897


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 2.023 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART B
DS20897

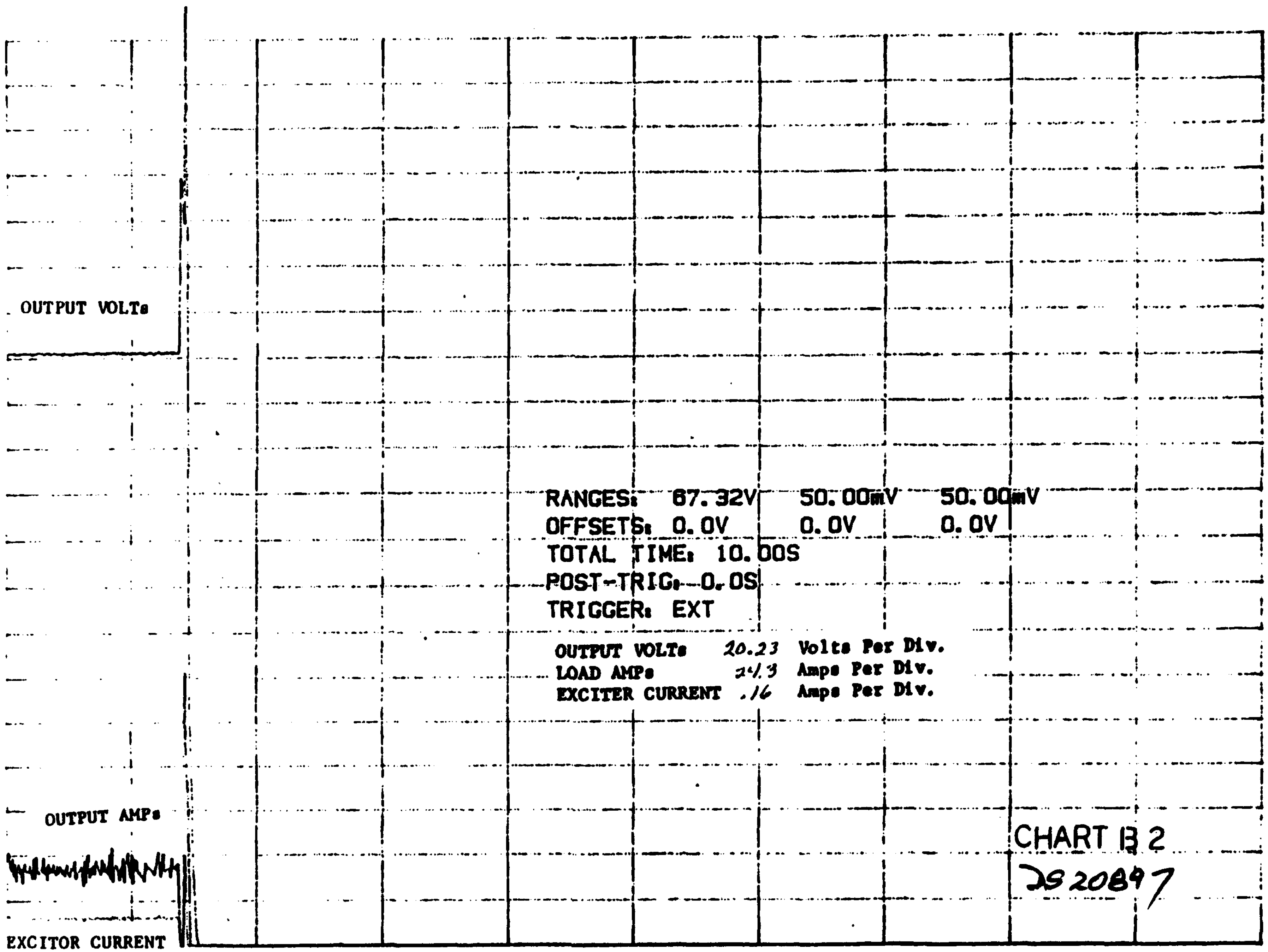

OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 14.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART B1
DS 20897

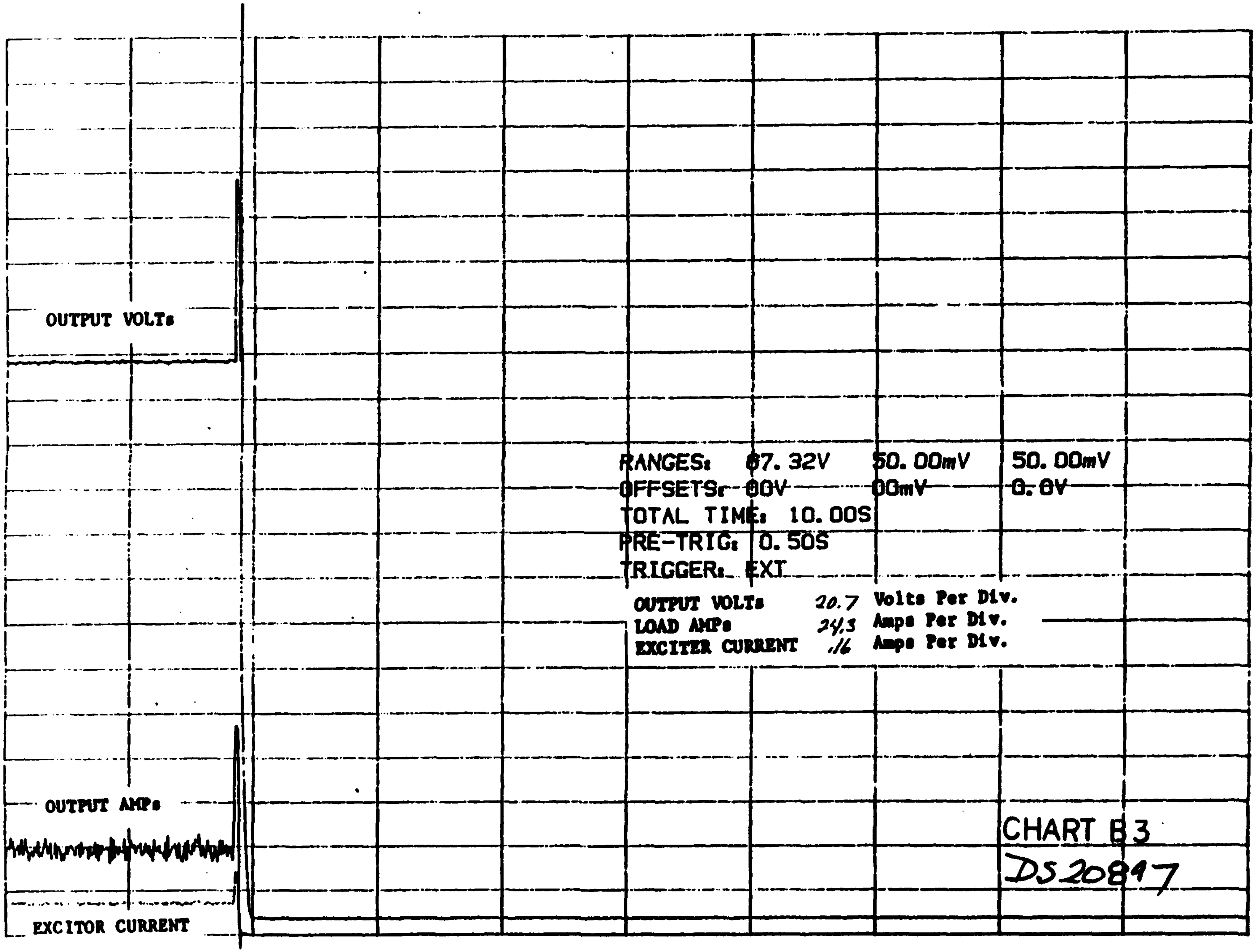


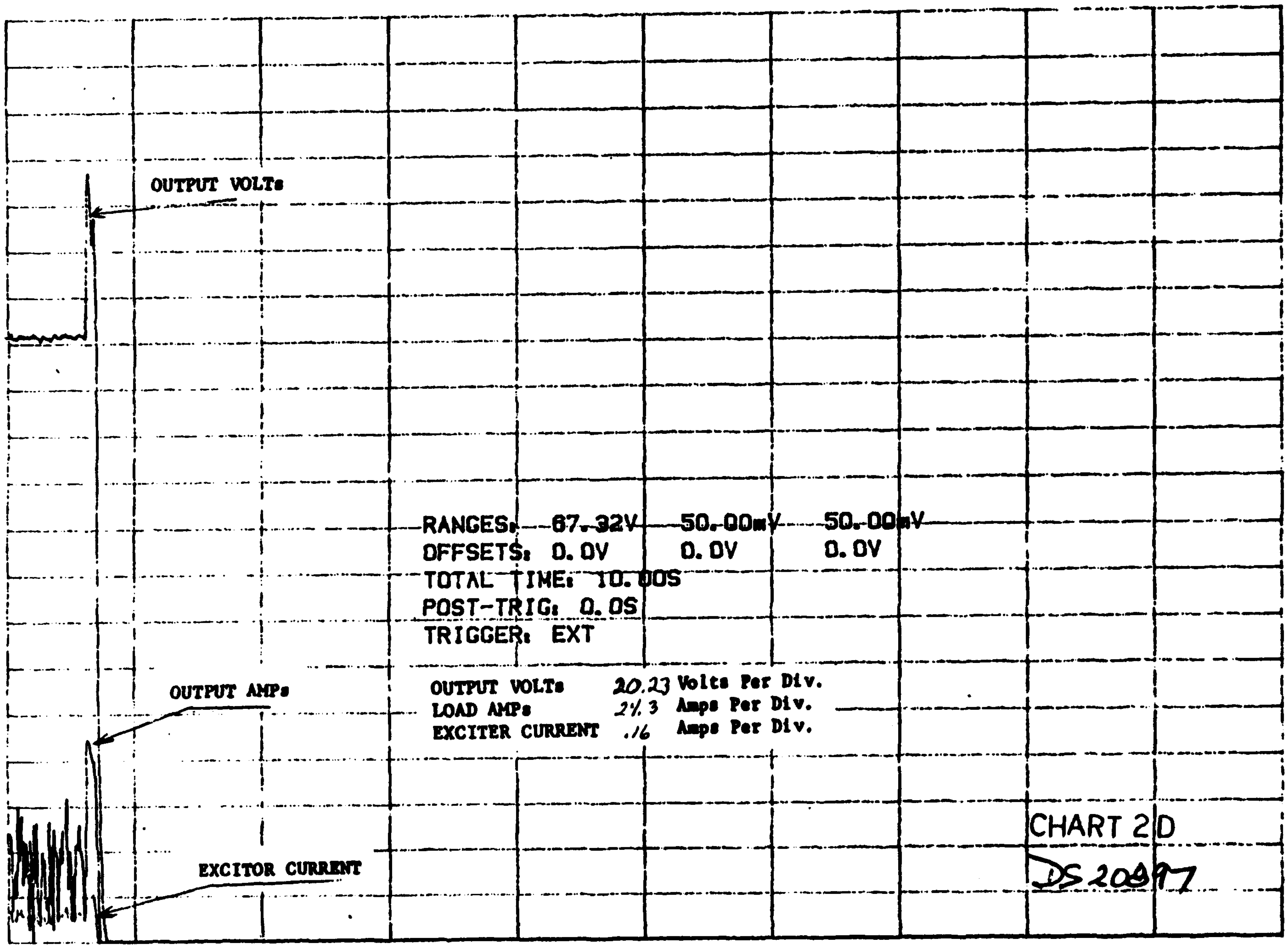
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 2B
DS 20897



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 94.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 2C
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART B 2
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART B3
DS20847


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 2D
DS 20897

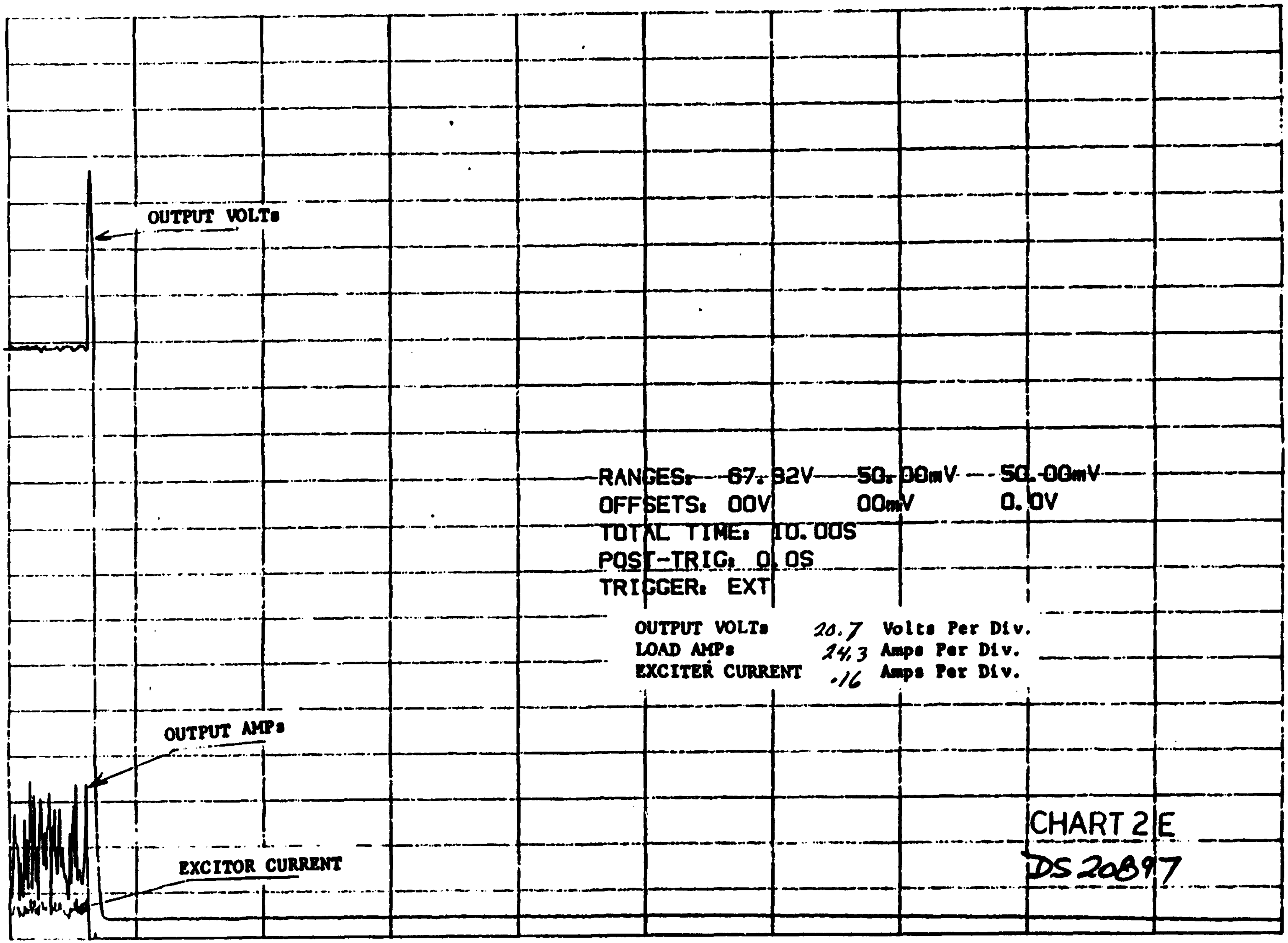
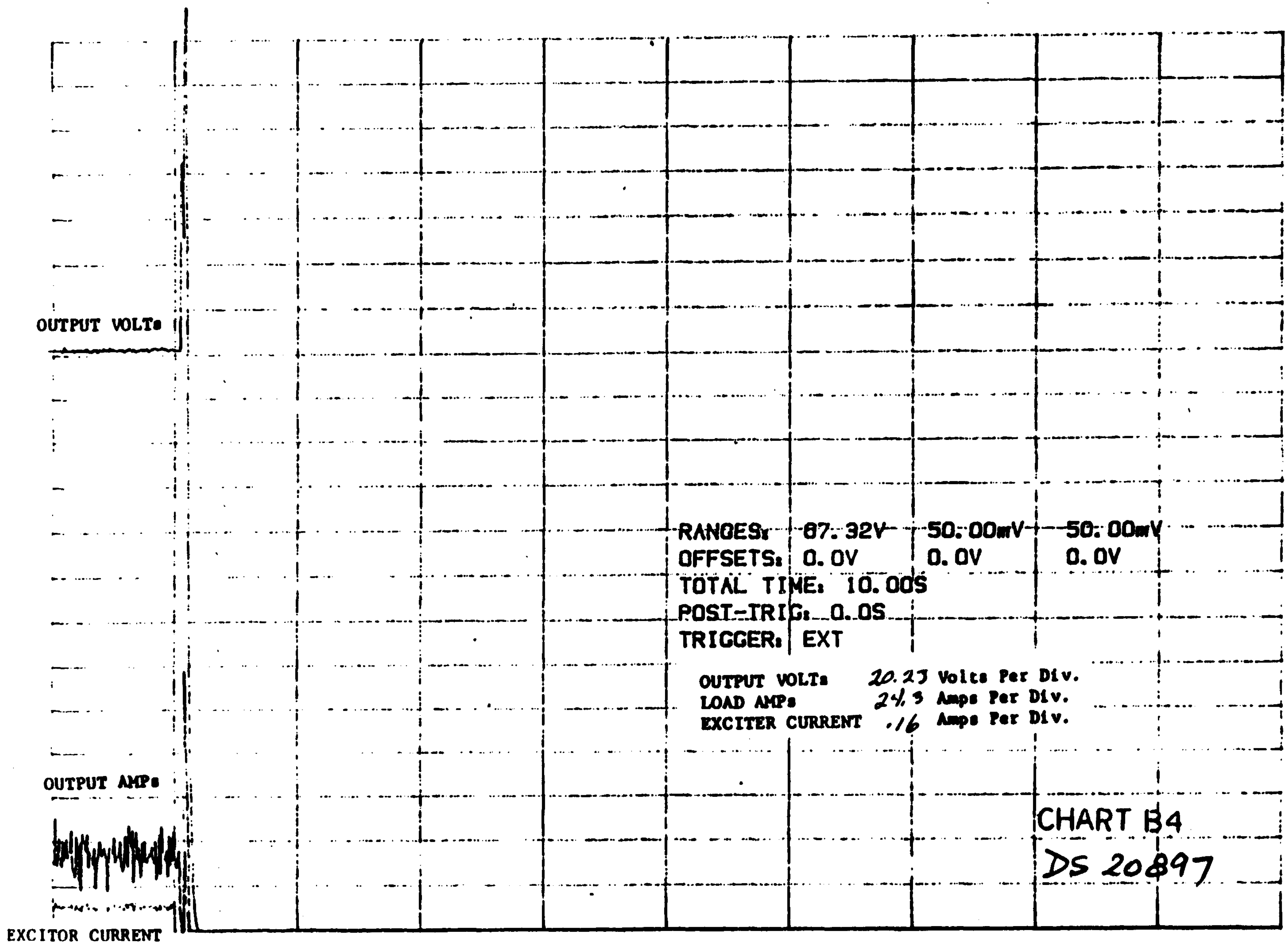
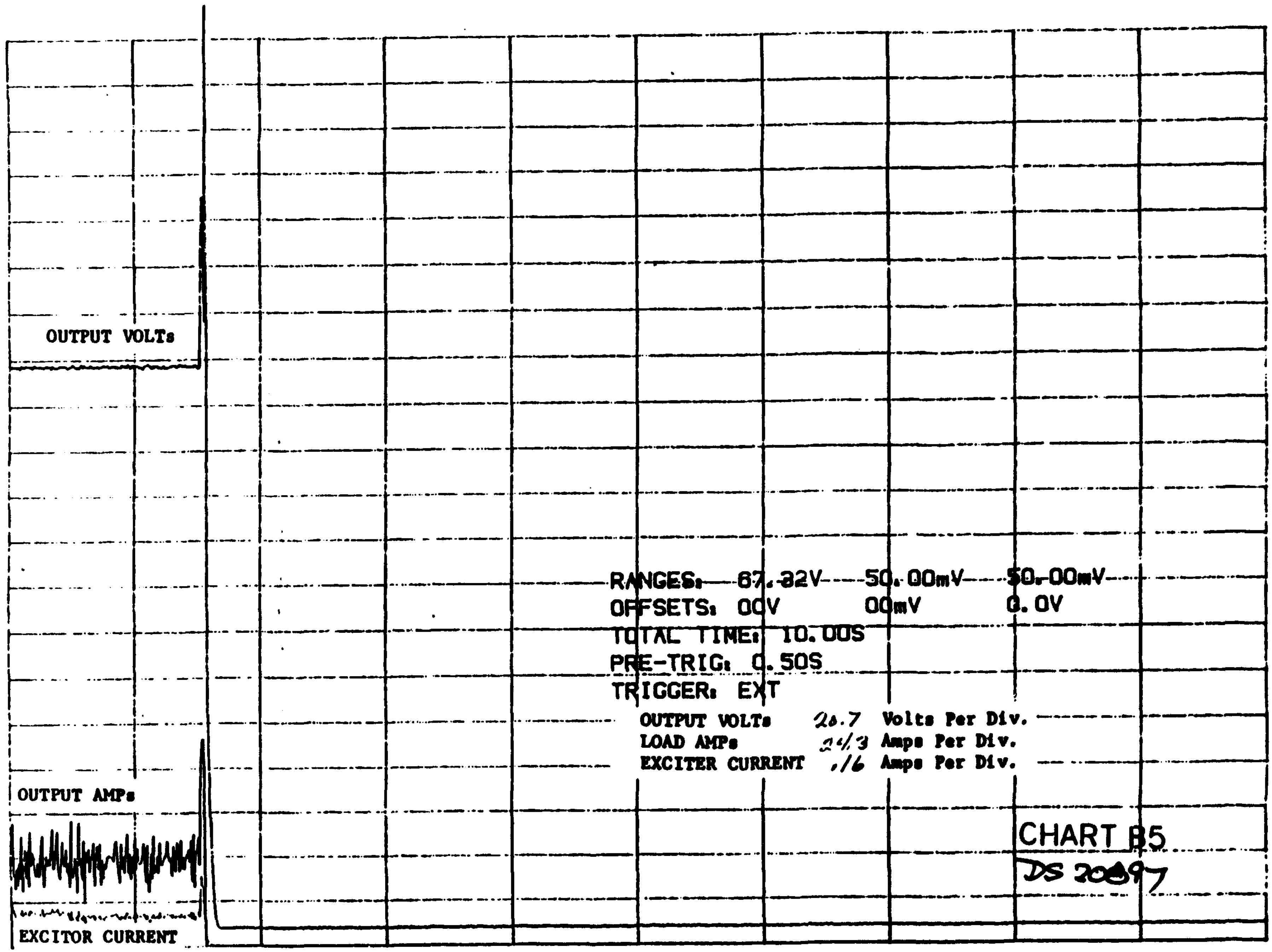


CHART 2 E

DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART B4
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 26.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART B5
DS 20897

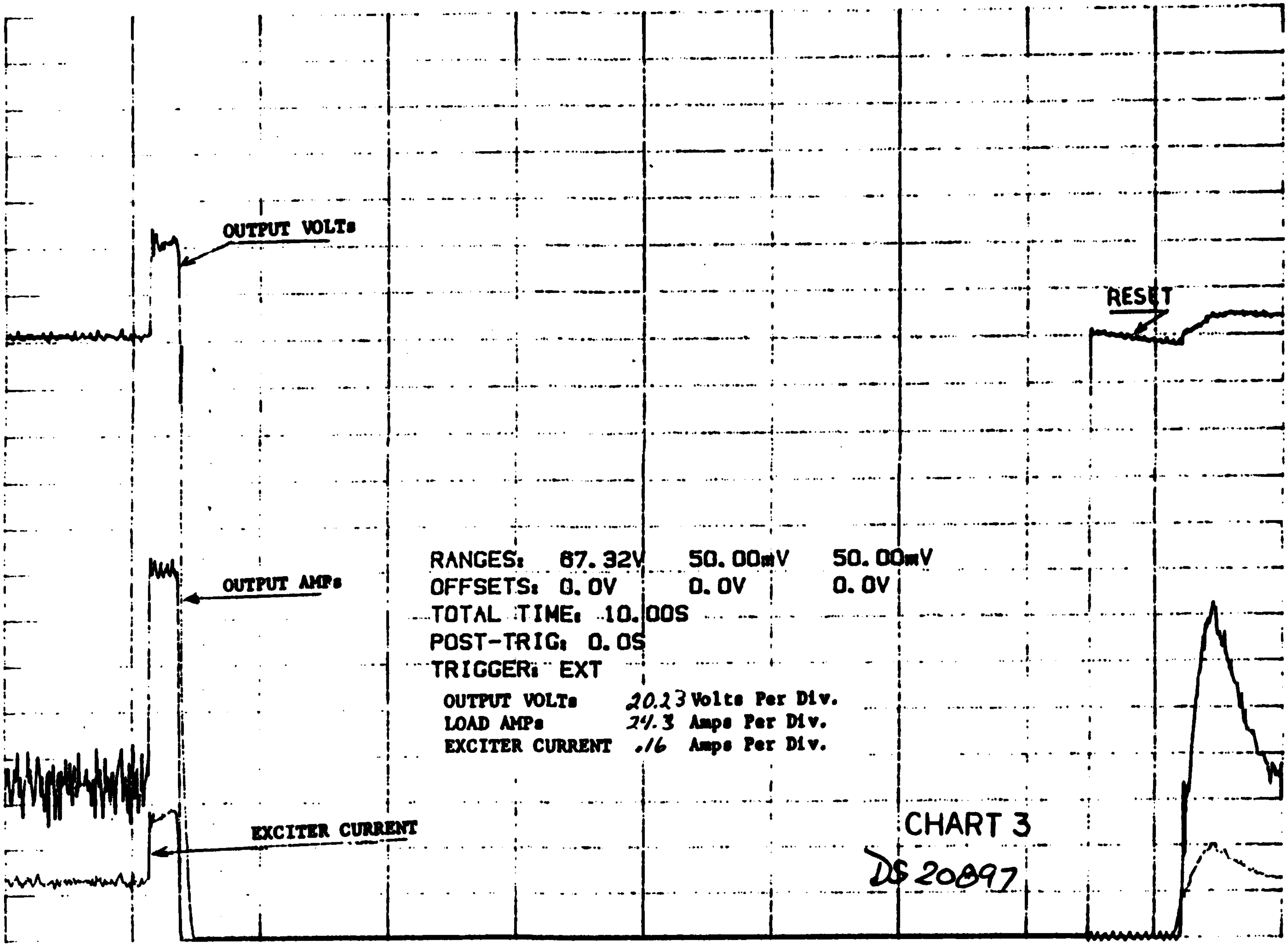
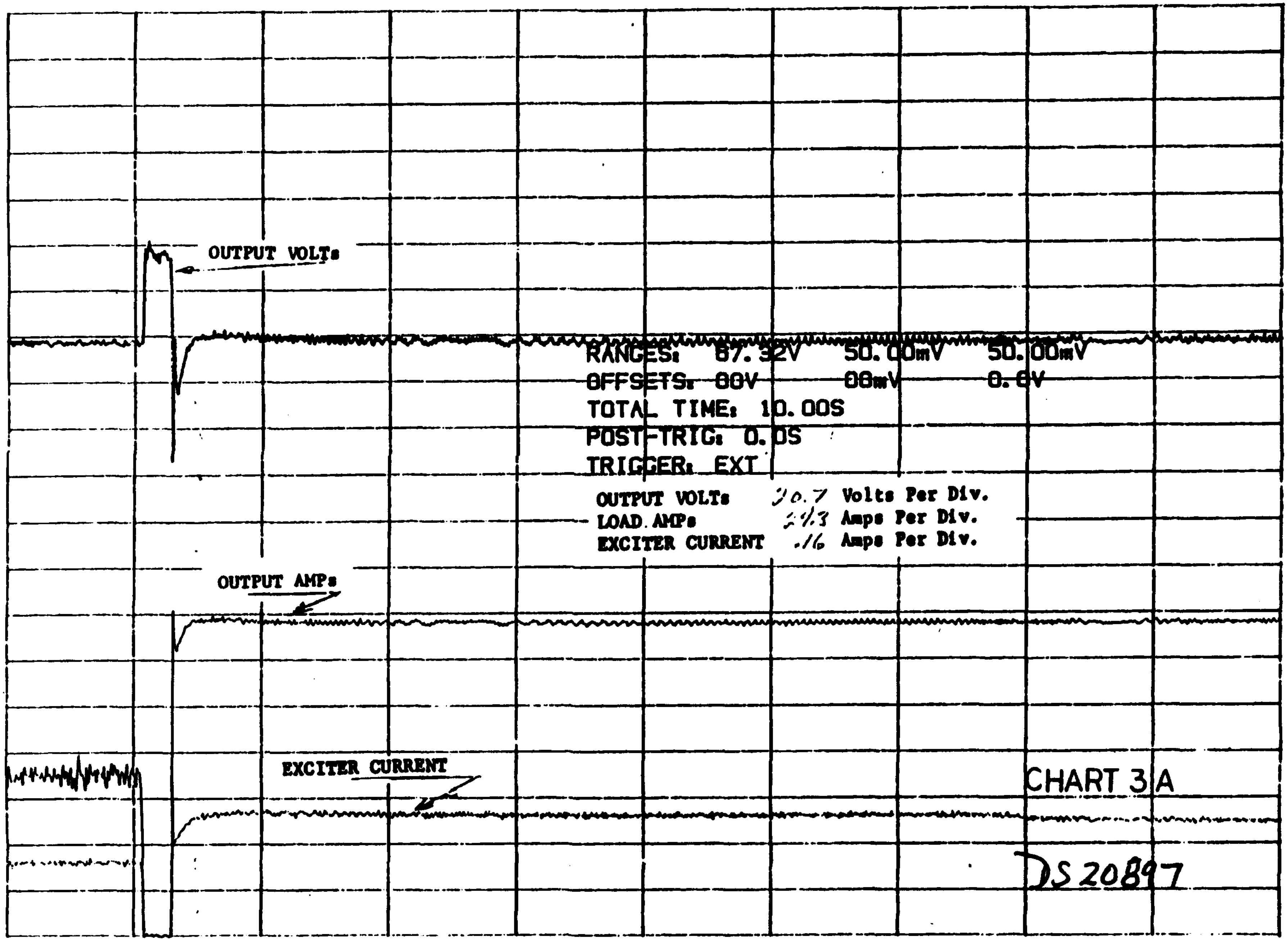
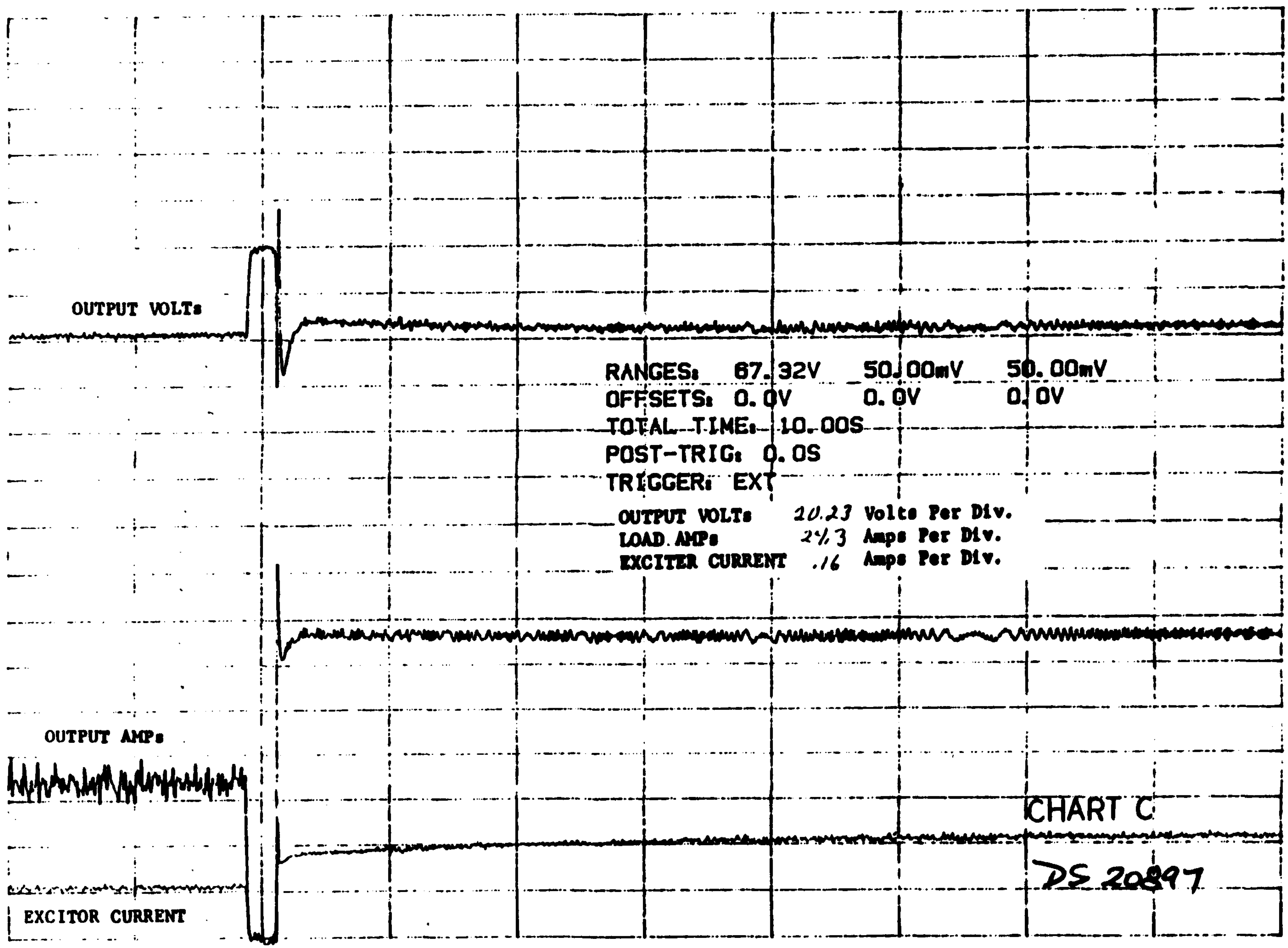
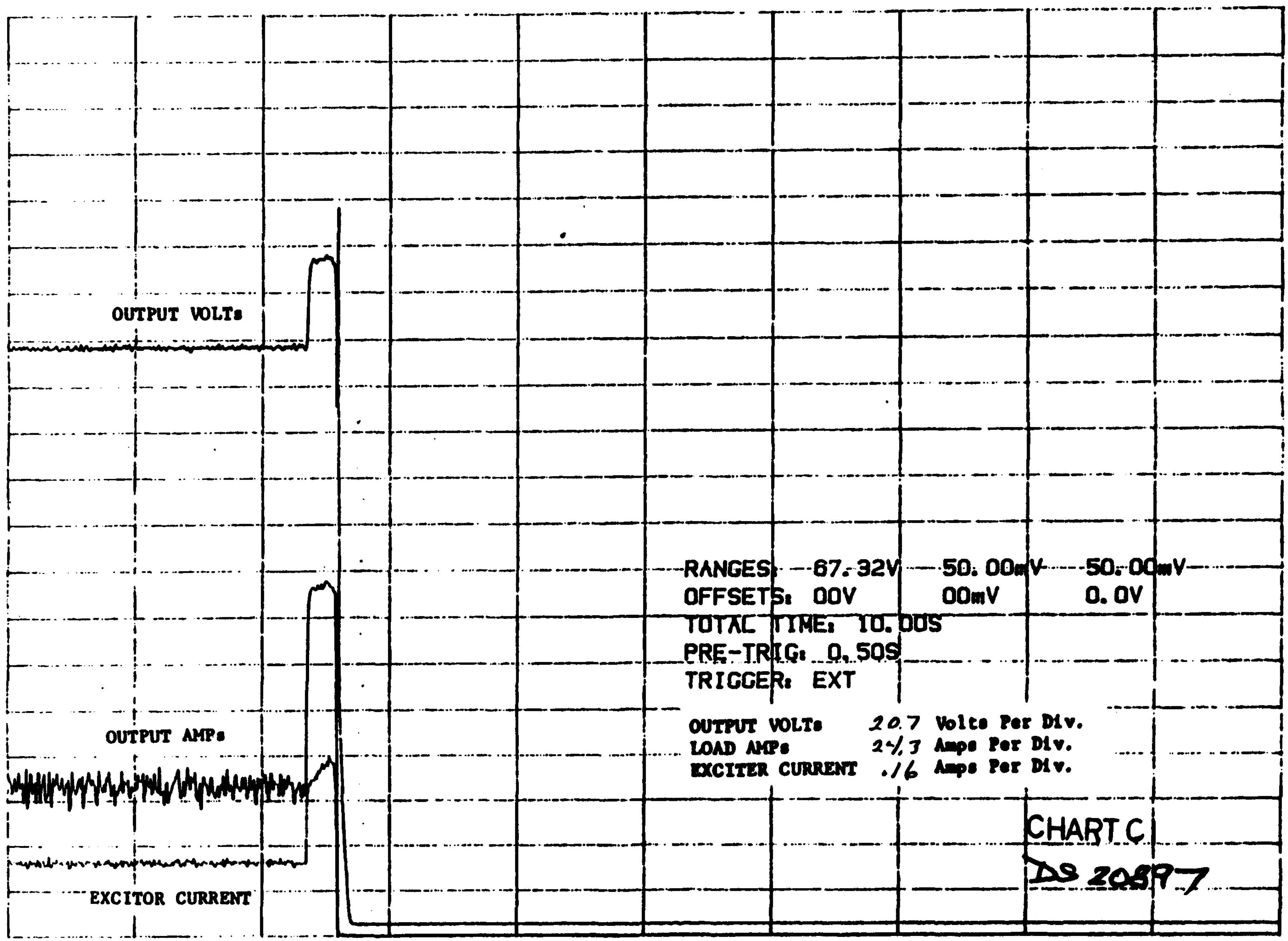


CHART 3

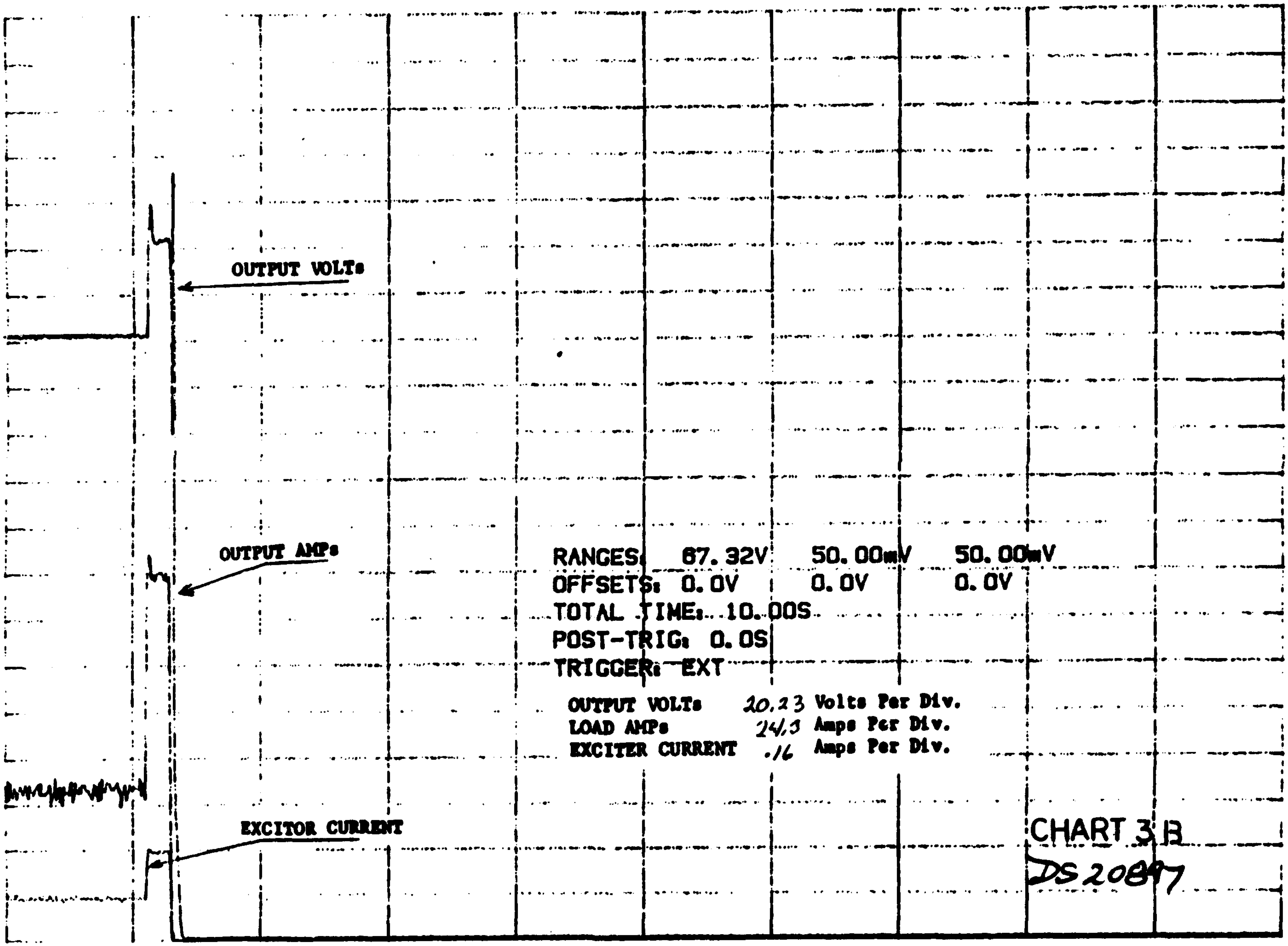
DS 20897


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITER CURRENT
CHART 3A
DS 20897

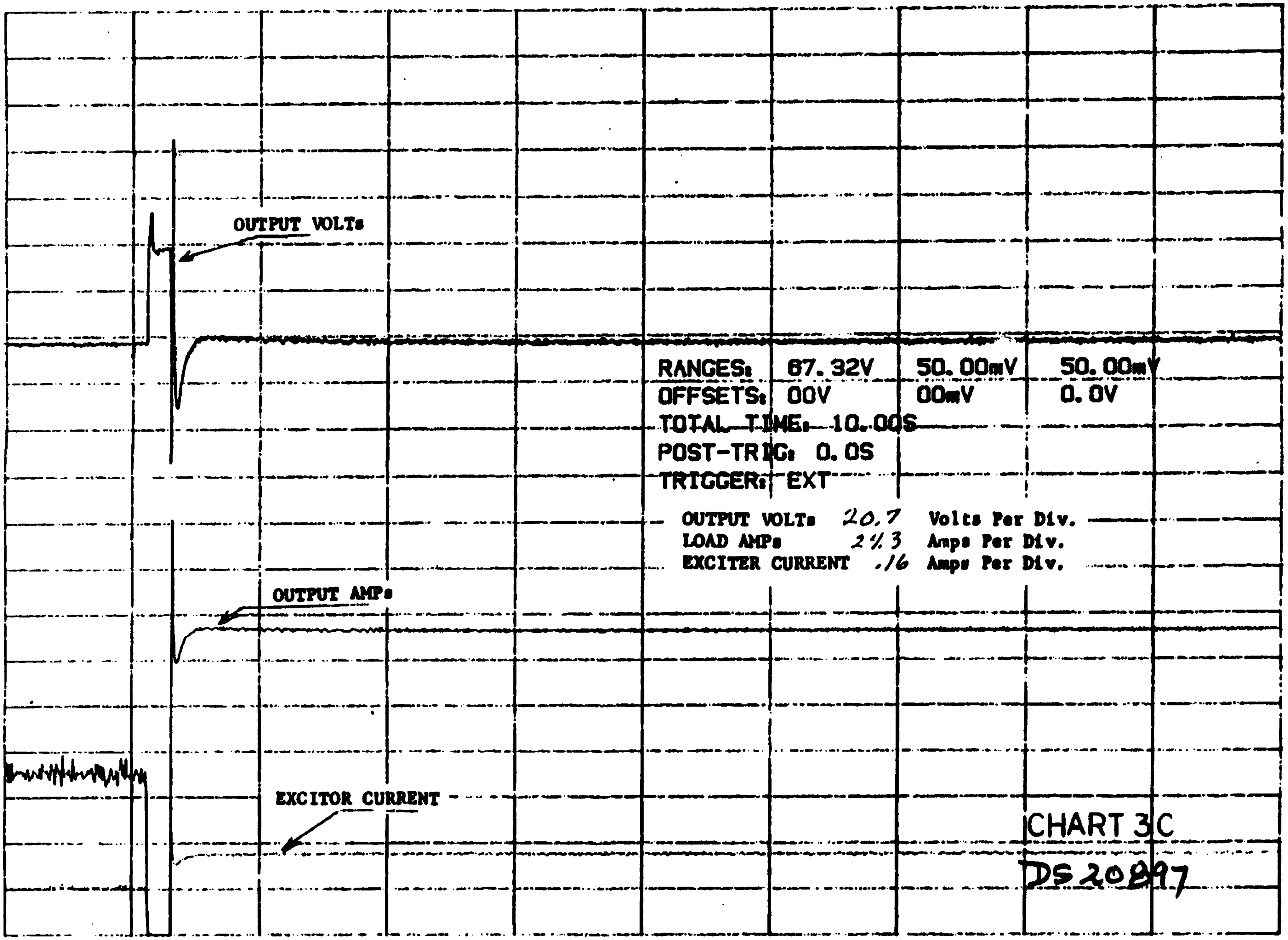

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 10.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART C
DS 20897

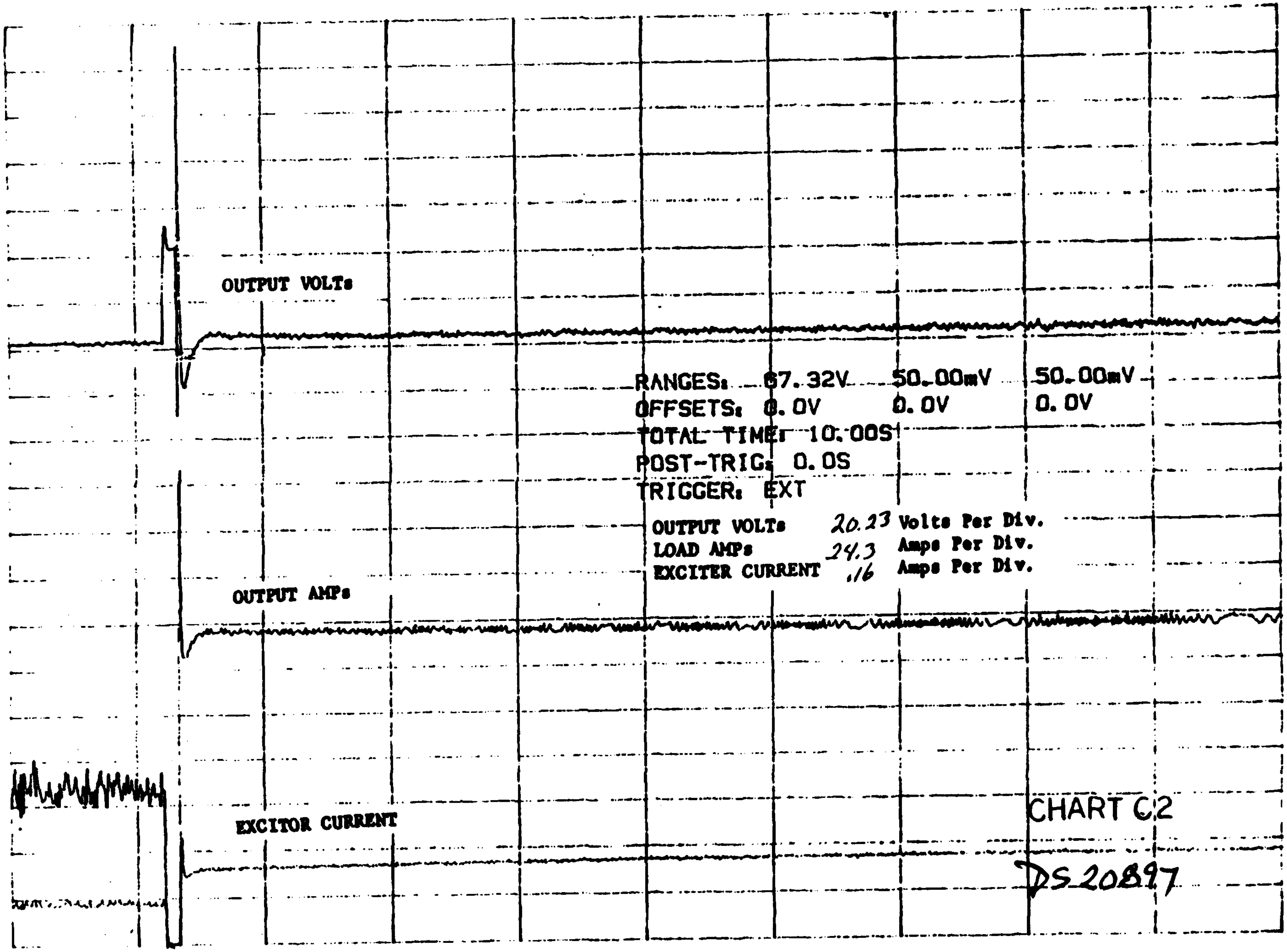


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART C
DS 20897

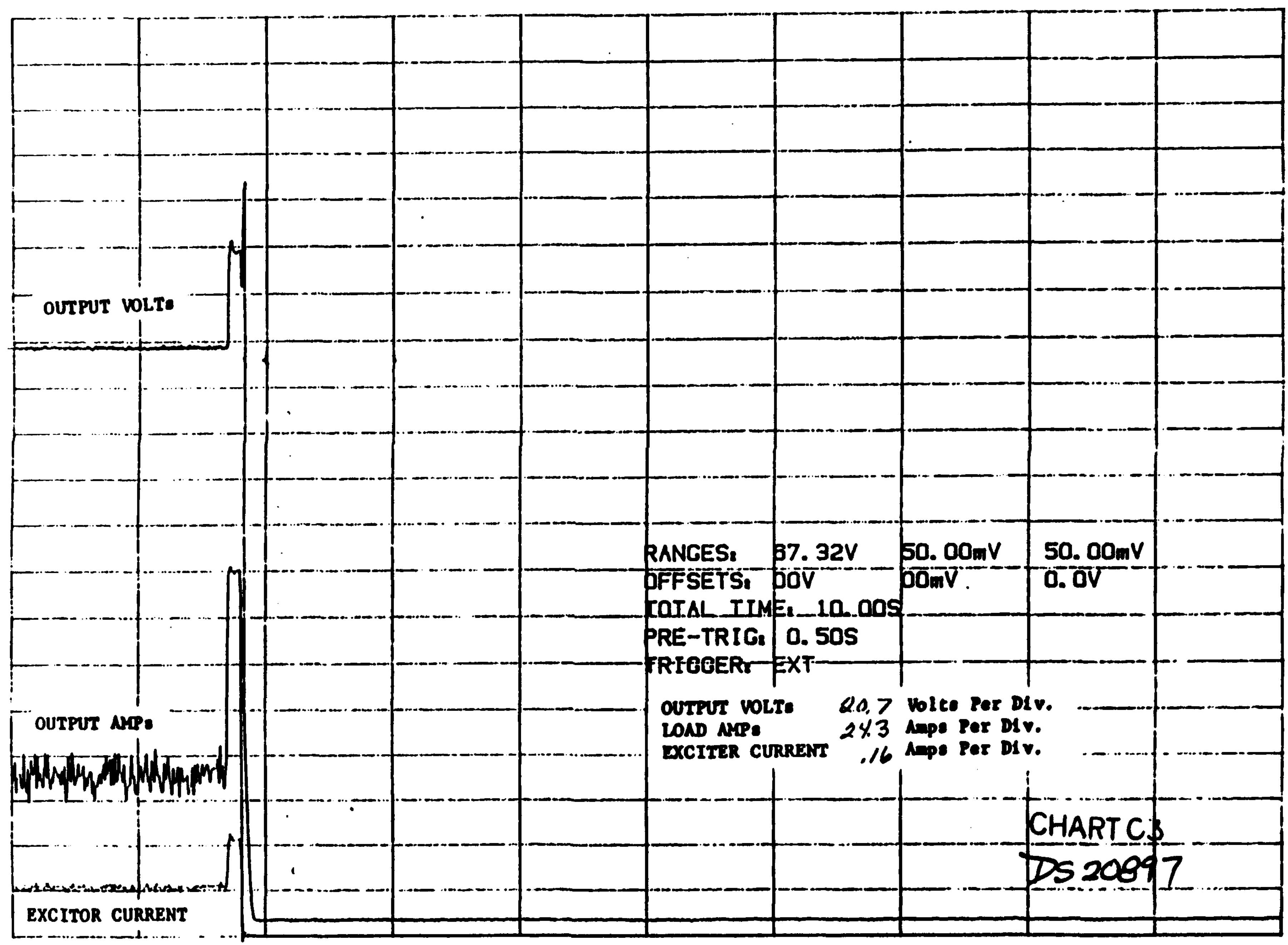


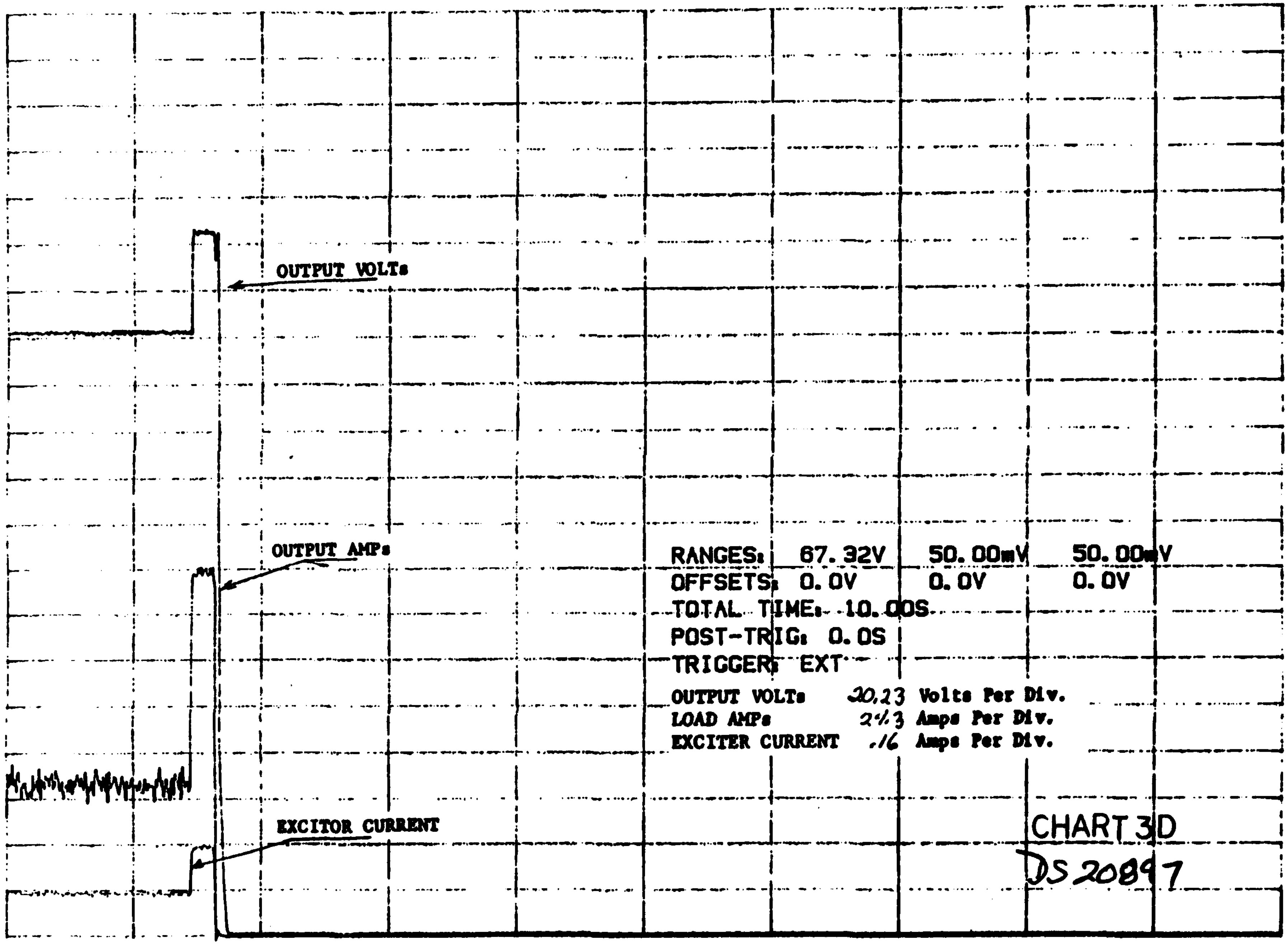
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 3 B
DS 20897

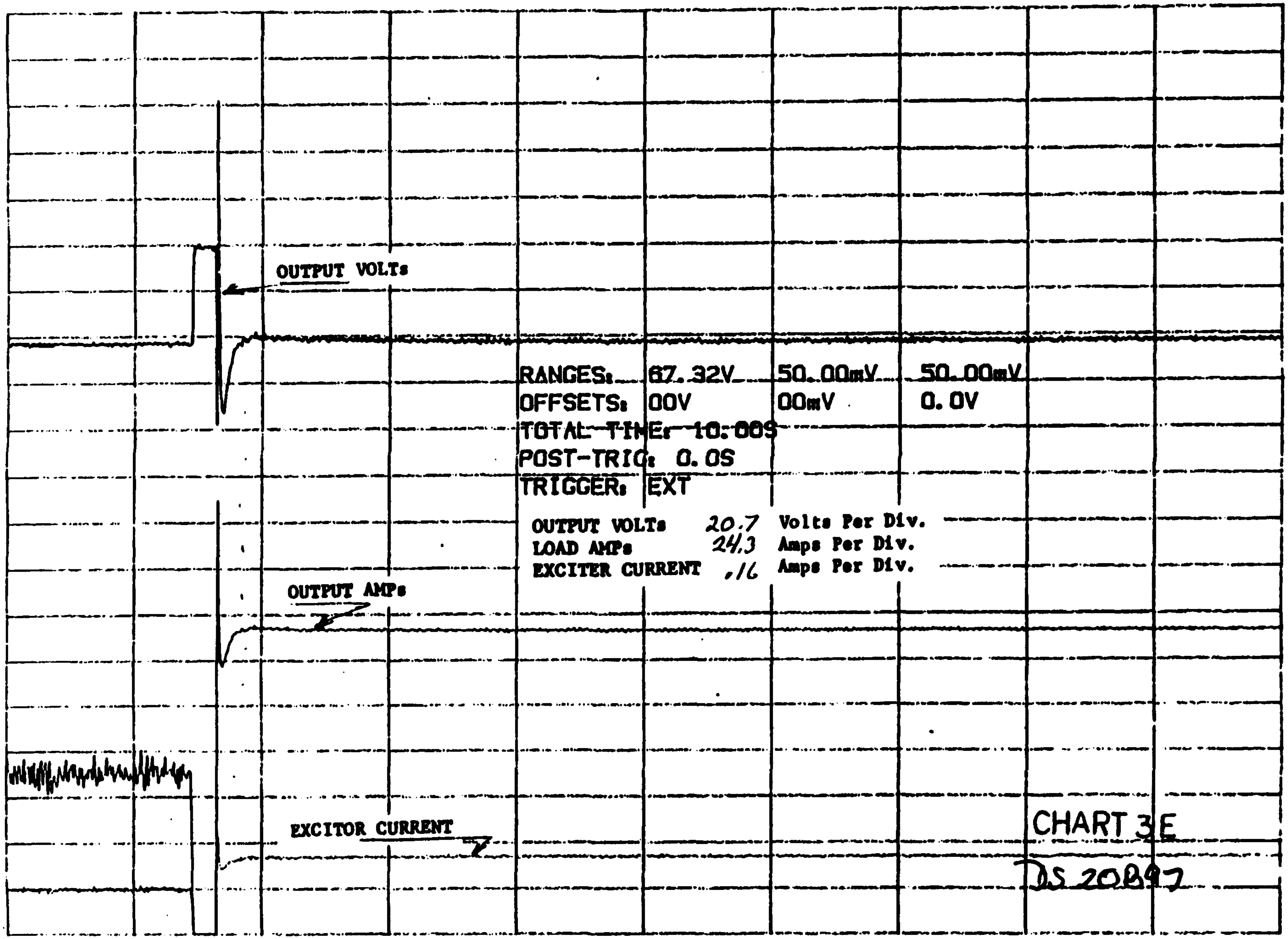

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 3C
DS 20897

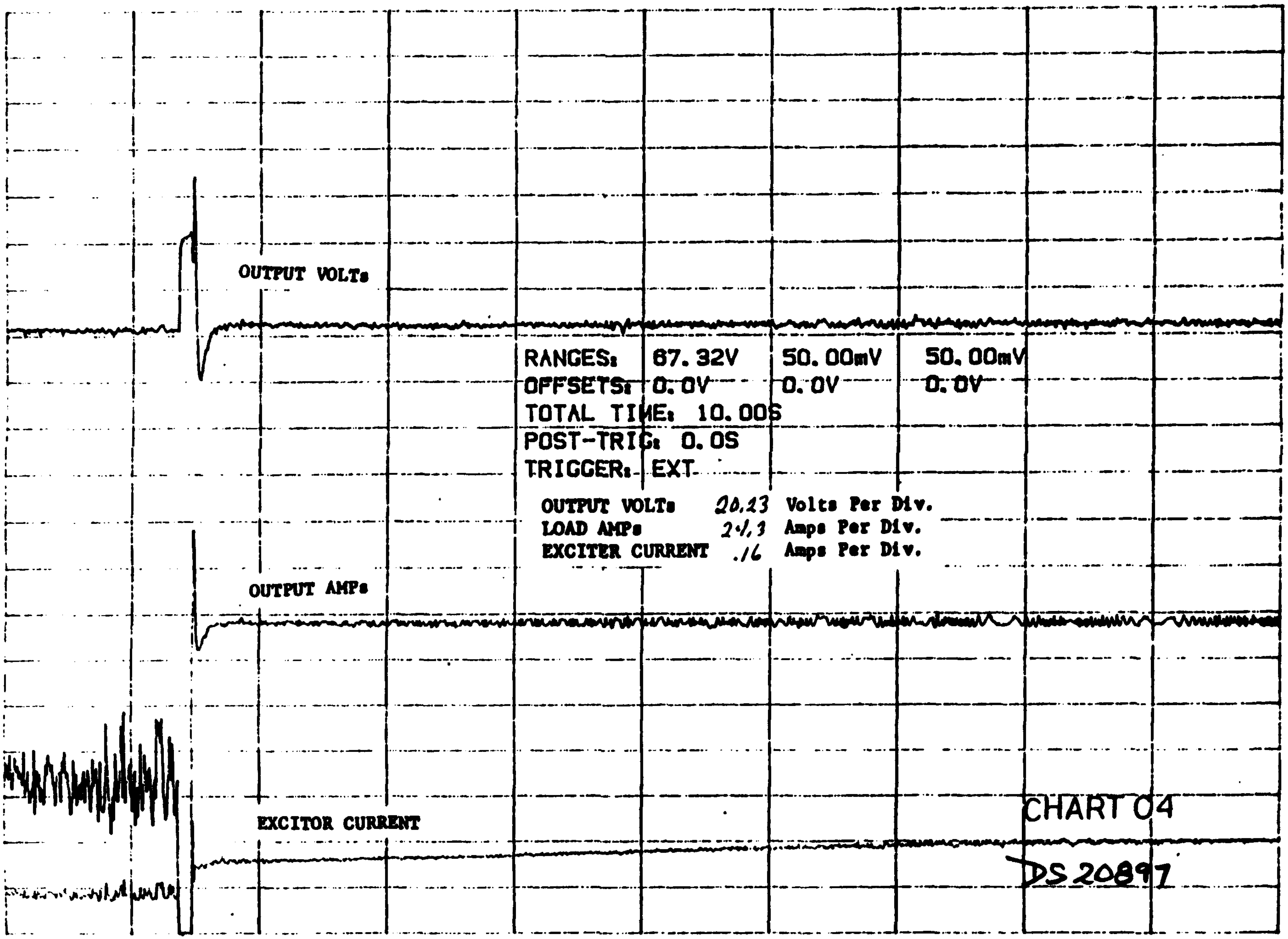


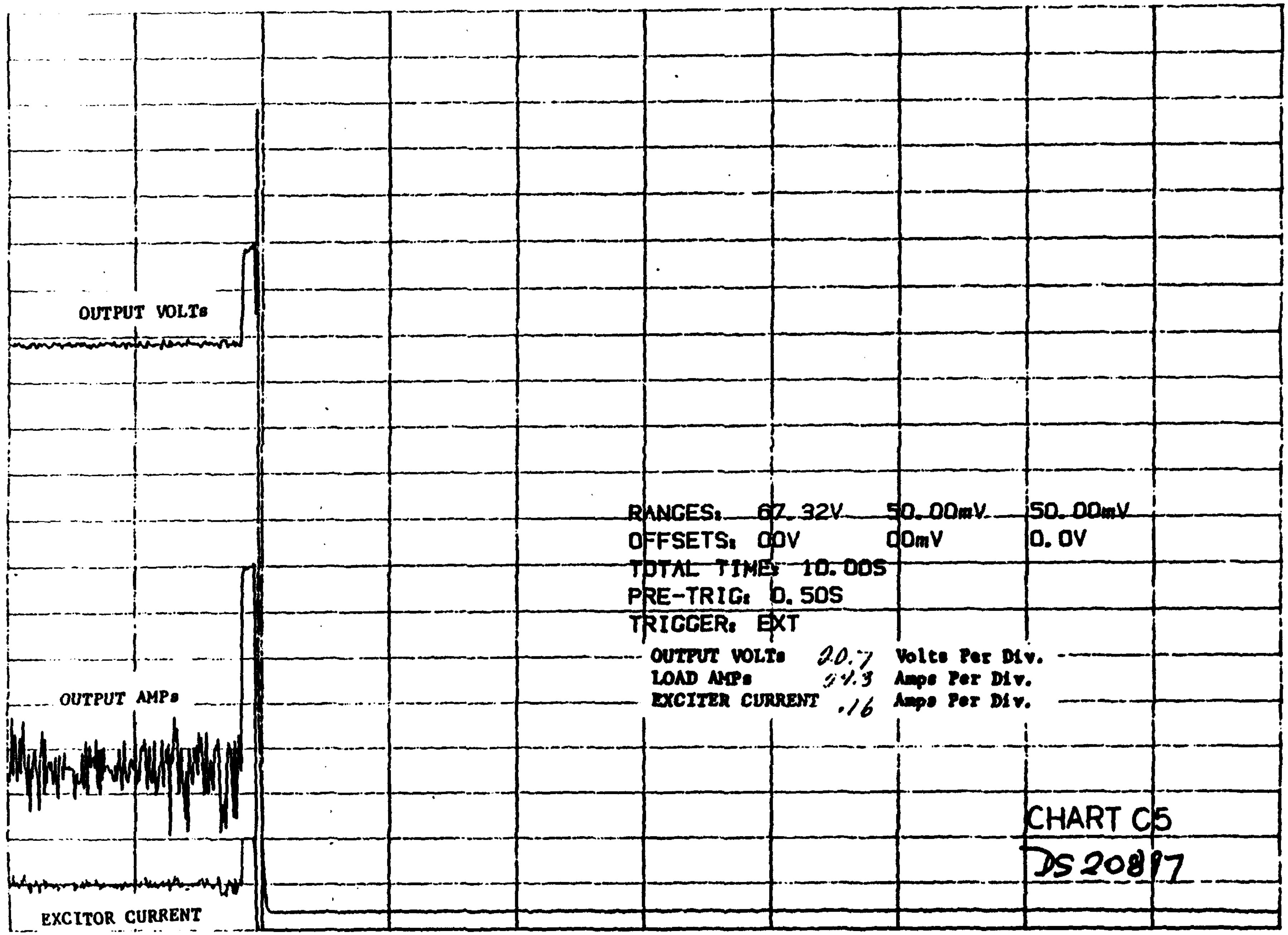
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART C2
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART C3
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 2½3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART 3D
DS 20897


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 3E
DS 20897


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 04
DS 20897


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 94.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.
CHART C5
DS 20897

5.10 <u>Undervoltage Function Trip</u>

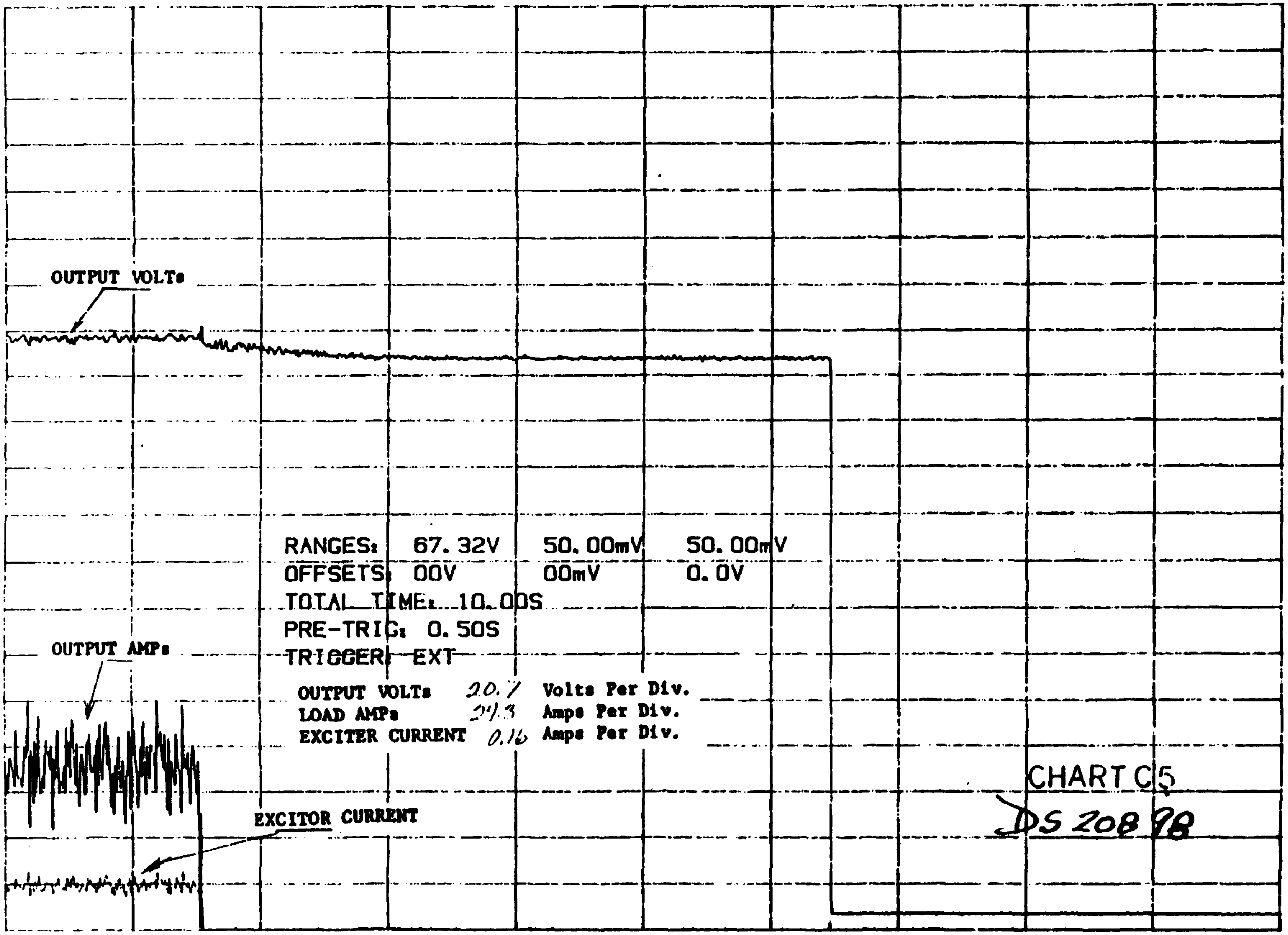
Purpose: The purpose of this test was to demonstrate the effectiveness of system protection when a fault exists on one channel of a parallel system resulting in an underexcitation-undervoltage condition.

Procedure: Two systems, I and II, were operated in parallel at 10,000, 16,000, and 18,000 rpm. At each of these speeds, tests were run at 0, 50, and 100% rated load with faults applied first to system I and then to system II.

Results: Test results are tabulated in Table 5-5. This table corresponds to LAPEC data sheet 20898 and accompanying charts.

Discussion of Results: The operation of the parallel system during underexcitation is greatly influenced by the load (provides bias to the undervoltage detection circuit) the specific system generator carries. Therefore, when the systems are operating no load (5 amperes pre-loads not included) no or the same bias is provided for the detectors. The opening of one system exciter field (underexcitation) will not affect the bias and therefore, the sensing circuit cannot detect the underexcited condition correctly (see traces 1 thru A5). Transients created by the "chattering" of switch opening create high overvoltage conditions sometimes resulting in the loss of both systems.

Underexcitation with the two systems carrying 167 amperes (see traces 3 thru C5) is properly detected and the faulty system isolated in approximately 5 seconds. Traces, identified as half-load (83.5 amperes) tests by data sheet DS2089B, were lost, only two traces "B" and "B1" were found. These show correct operation of system II (faulted) undervoltage protection. The above test results show, that the detection of underexcitation needs to be improved to the condition of no-load (or very light load) conditions as well, by sensing the exciter field current along with the load current for the detection of underexcitation.



OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART C5
DS 208 98

TABLE 5-5

UNDEREXCITATION/UNDERVOLTAGE FUNCTION TRIP

RPM	% Load	Syst. Faulted	Max. Volts Syst. I	Max. Volts Syst. II	Chart No. Syst. I	Chart No. Syst. II
10,000	0	I	339	330	1	1A
10,000	0	II	325	321	A	A1
16,000	0	I	421	433	1B	1C
16,000	0	II	423	428	A2	A3
18,000	0	I	423	427	1D	1E
18,000	0	II	346	341	A4	A5
10,000	50	I	INDETERMINATE		2	2A
10,000	50	II	INDETERMINATE		B	B1
16,000	50	I	INDET.	303	2B	2C
16,000	50	II	399	372	B2	B3
18,000	50	I	420	312	2D	2E
18,000	50	II	403	396	B4	B5
10,000	100	I	INDETERMINATE		3	3A
10,000	100	II	INDETERMINATE		C	C1
16,000	100	I	INDETERMINATE		3B	3C
16,000	100	II	INDETERMINATE		C2	C3
18,000	100	I	INDETERMINATE		3D	3E
18,000	100	II	INDETERMINATE		C4	C5

L··AS AEROSPACE
PC·· EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. L-Harkert

E.W.O. 54805 MODEL NO. SYSTEMS I + II SERIAL NO. GEN XL-4 / 121, GCU 104 / 103, CURRENT SENSORS 121 / 126 / 125 / 126 ROTOR NO. STATOR NO.

DATE OF TEST 12/23/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

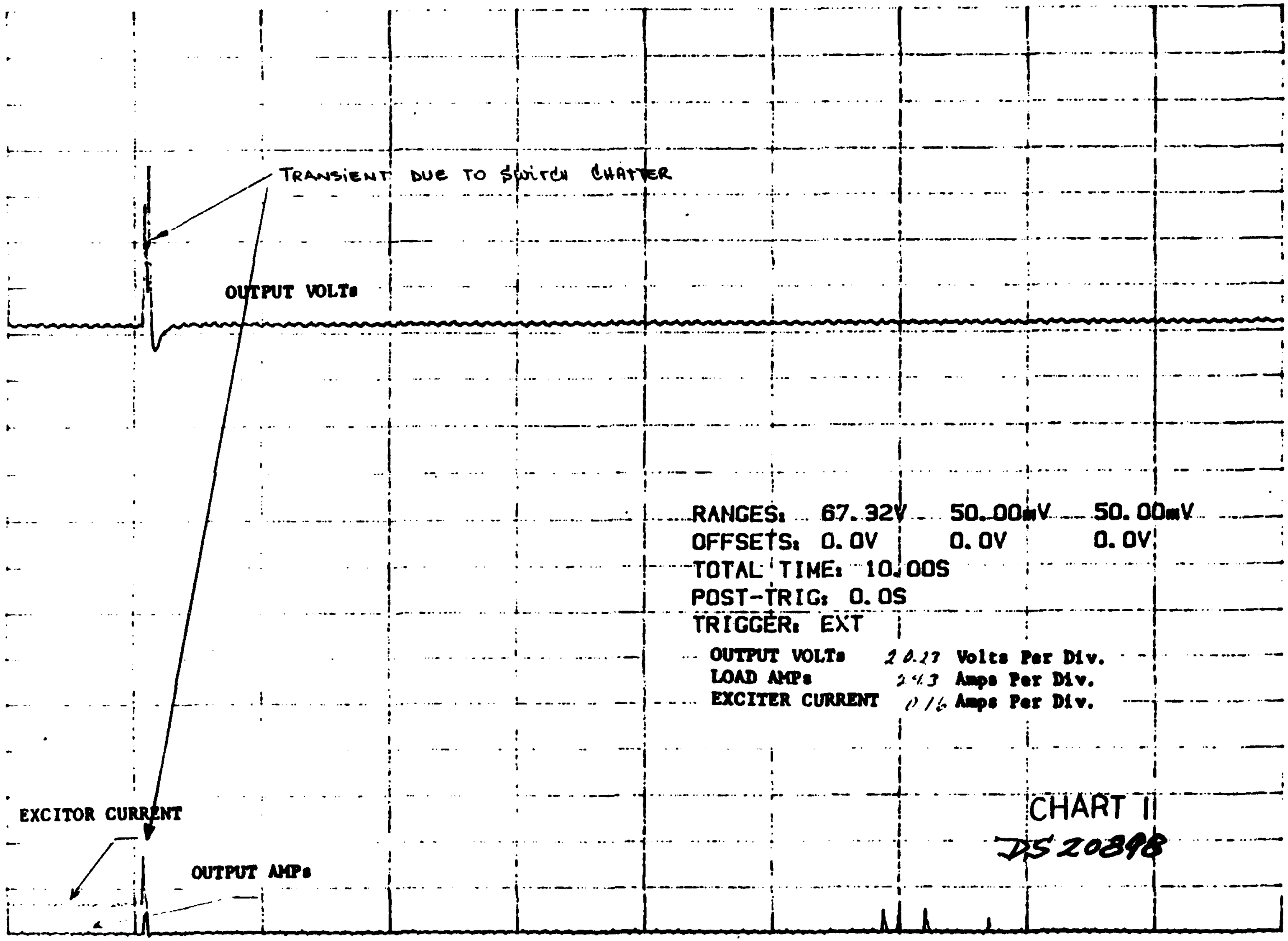
BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

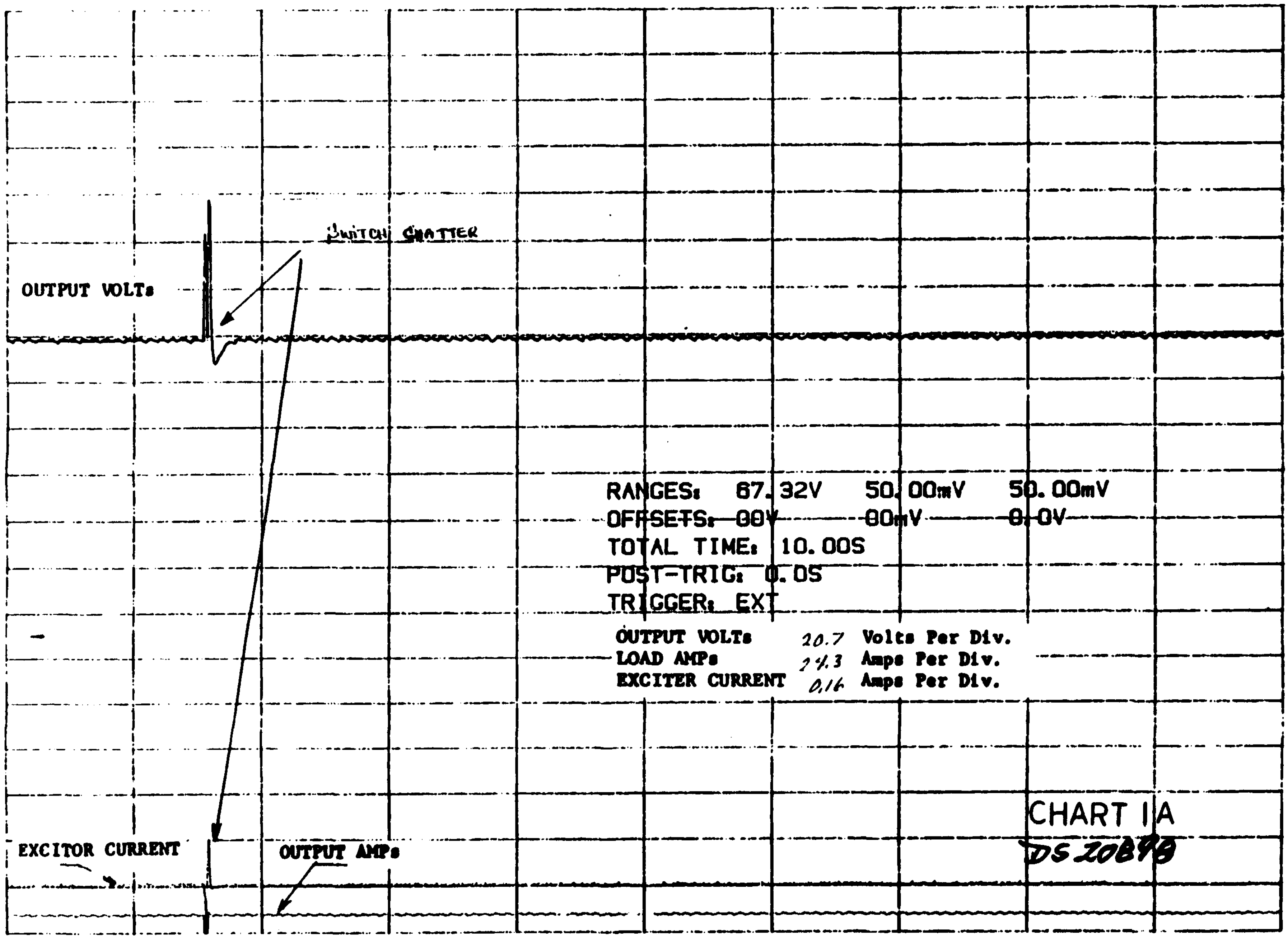
PAGE OF

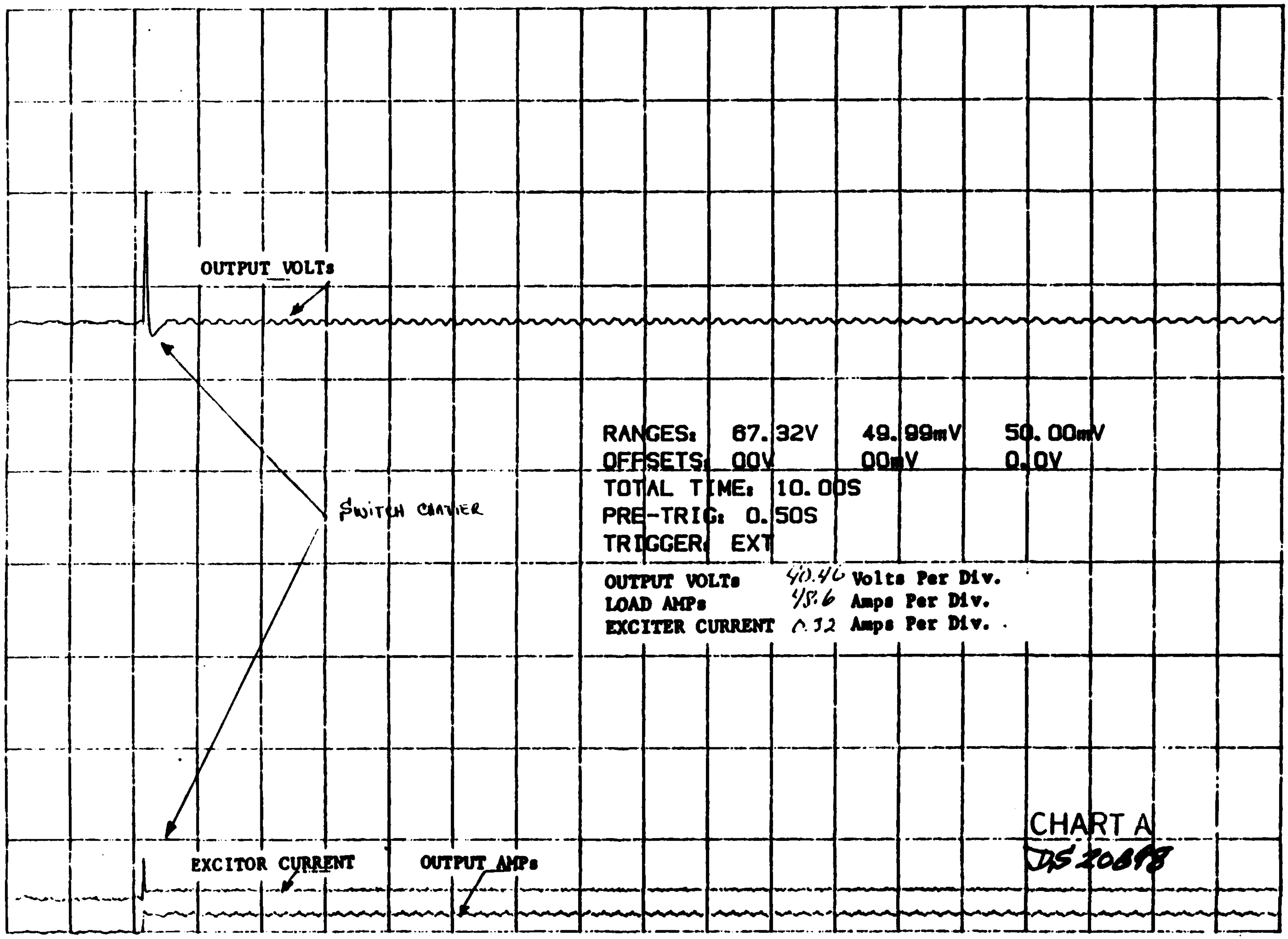
TITLE: 4.13 UNDEREXCITATION/UNDERVOLTAGE FUNCTION TRIP

PARA. NO.	TIME	AMB. TEMP.	Fault	Chart		Load	Current	%	Chart		Fault	System	Stator
10000	SYS	I	FAULTED	CHART	1	NO LOAD		0%	CHART	A	—	SYS	I
10000	SYS	II	—	CHART	1A	NO LOAD		0%	CHART	A1	FAULTED	SYS	II
16000	SYS	I	FAULTED	CHART	1B	NO LOAD		0%	CHART	A2	—	SYS	I
16000	SYS	II	—	CHART	1C	NO LOAD		0%	CHART	A3	FAULTED	SYS	II
18000	SYS	I	FAULTED	CHART	1D	NO LOAD		0%	CHART	A4	—	SYS	I
18000	SYS	II	—	CHART	1E	NO LOAD		0%	CHART	A5	FAULTED	SYS	II
10000	SYS	I	FAULTED	CHART	2	LOAD	83.5A	50%	CHART	B	—	SYS	I
10000	SYS	II	—	CHART	2A	LOAD	83.5A	50%	CHART	B1	FAULTED	SYS	II
16000	SYS	I	FAULTED	CHART	2B	LOAD	83.5A	50%	CHART	B2	—	SYS	I
16000	SYS	II	—	CHART	2C	LOAD	83.5A	50%	CHART	B3	FAULTED	SYS	II
18000	SYS	I	FAULTED	CHART	2D	LOAD	83.5A	50%	CHART	B4	—	SYS	I
18000	SYS	II	—	CHART	2E	LOAD	83.5A	50%	CHART	B5	FAULTED	SYS	II
10000	SYS	I	FAULTED	CHART	3	LOAD	167A	100%	CHART	C	—	SYS	I
10000	SYS	II	—	CHART	3A	LOAD	167A	100%	CHART	C1	FAULTED	SYS	II
16000	SYS	I	FAULTED	CHART	3B	LOAD	167A	100%	CHART	C2	—	SYS	I
16000	SYS	II	—	CHART	3C	LOAD	167A	100%	CHART	C3	FAULTED	SYS	II
18000	SYS	I	FAULTED	CHART	3D	LOAD	167A	100%	CHART	C4	—	SYS	I
18000	SYS	II	—	CHART	3E	LOAD	167A	100%	CHART	C5	FAULTED	SYS	II

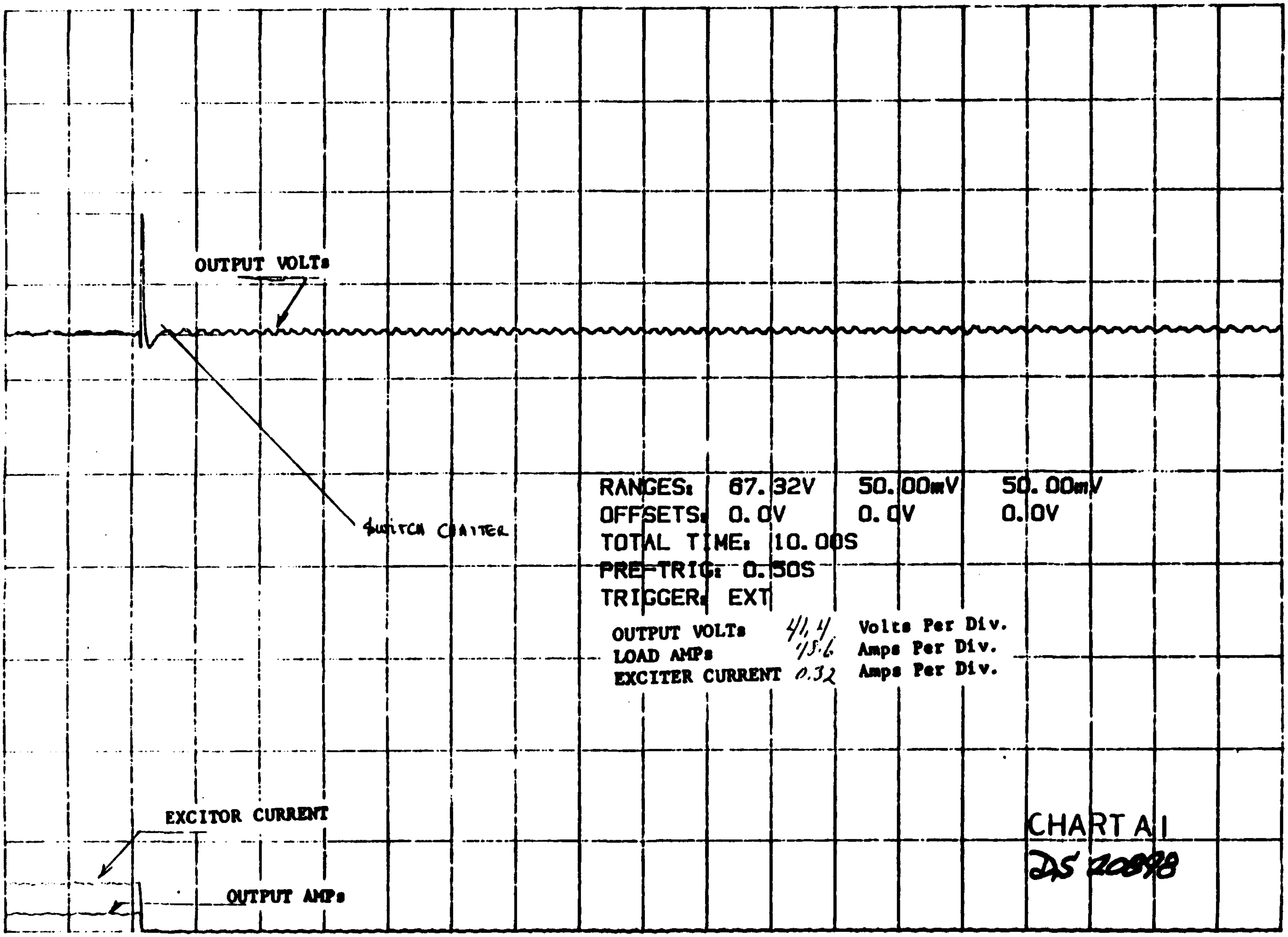
FOLLOWING

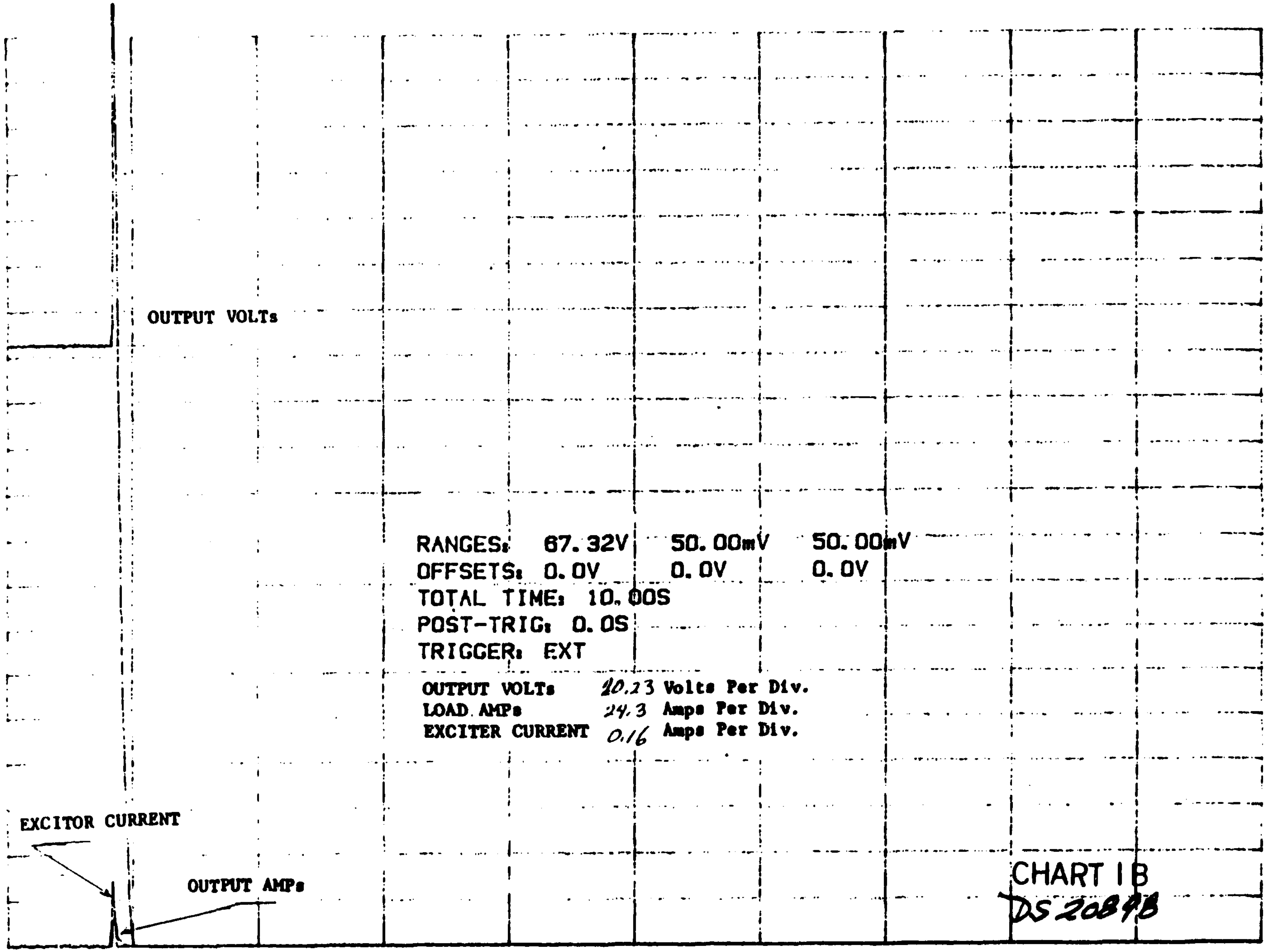

TRANSIENT DUE TO SWITCH CHATTER
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 2 4.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART II
DS 20898

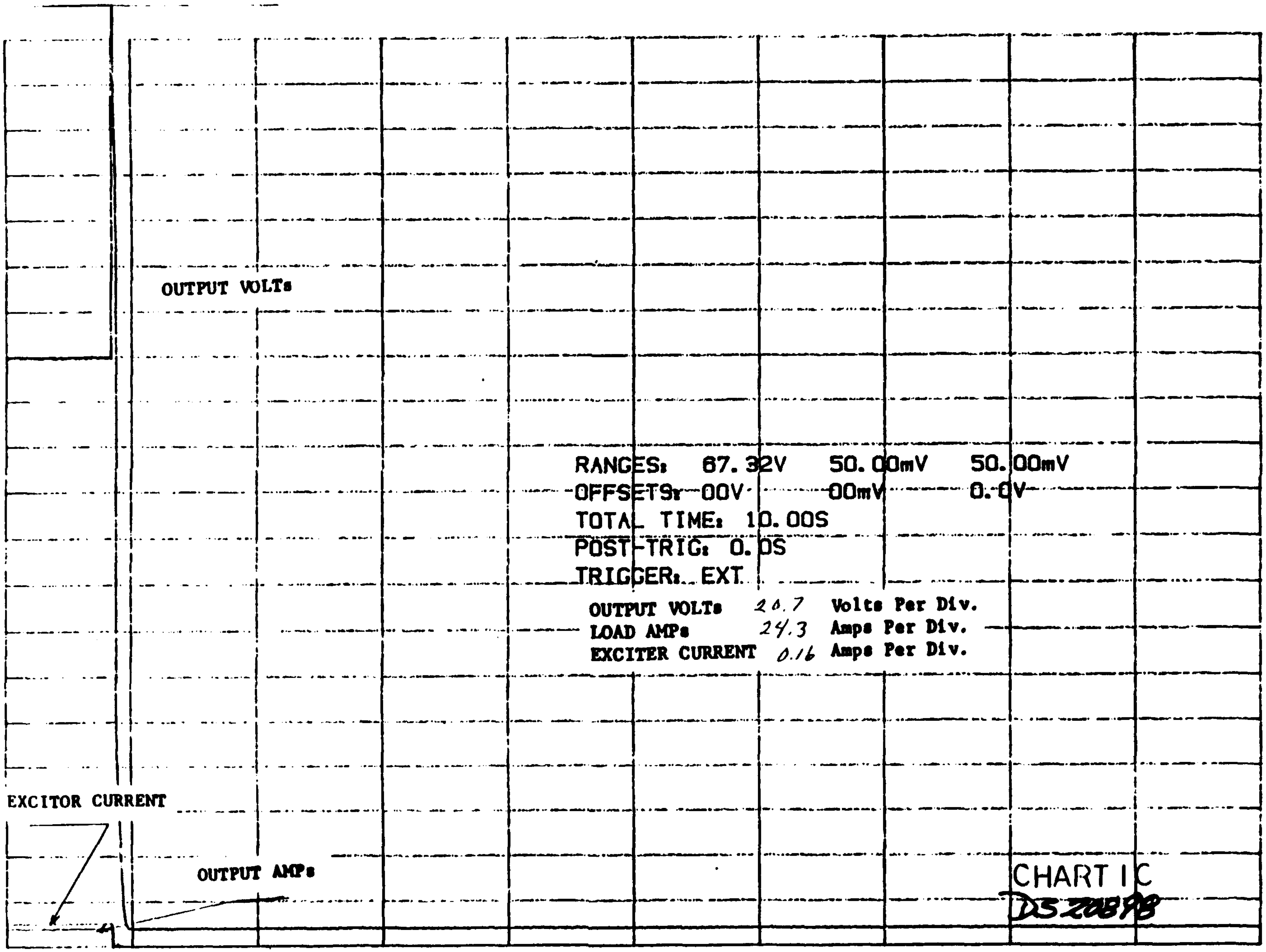

SWITCH CHATTER
OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART IIA
DS 20898

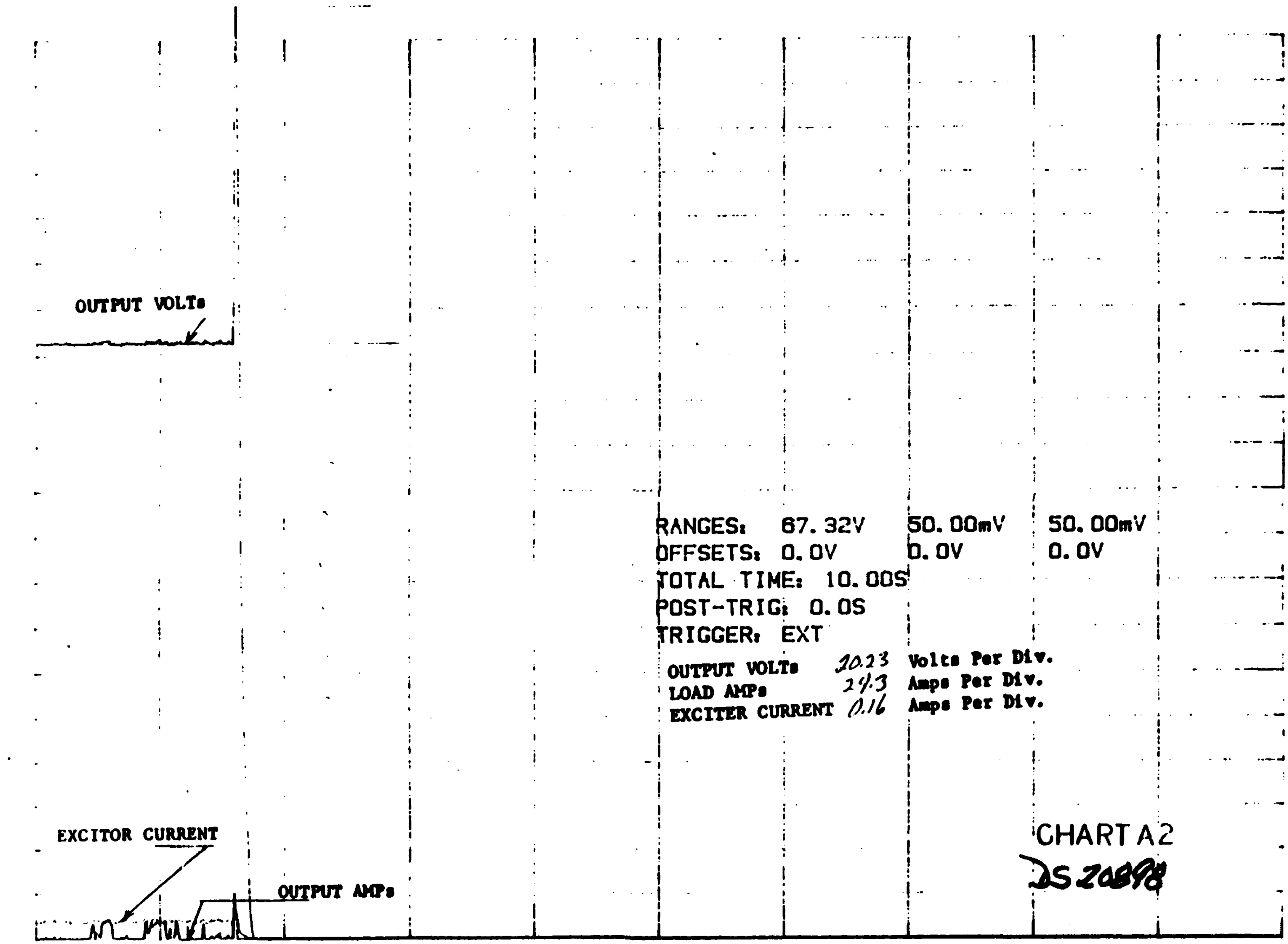


OUTPUT VOLTs
SWITCH CHATIER
RANGES: 67.32V 49.99mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 40.46 Volts Per Div.
LOAD AMPs 48.6 Amps Per Div.
EXCITER CURRENT 0.32 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART A
DS 20898

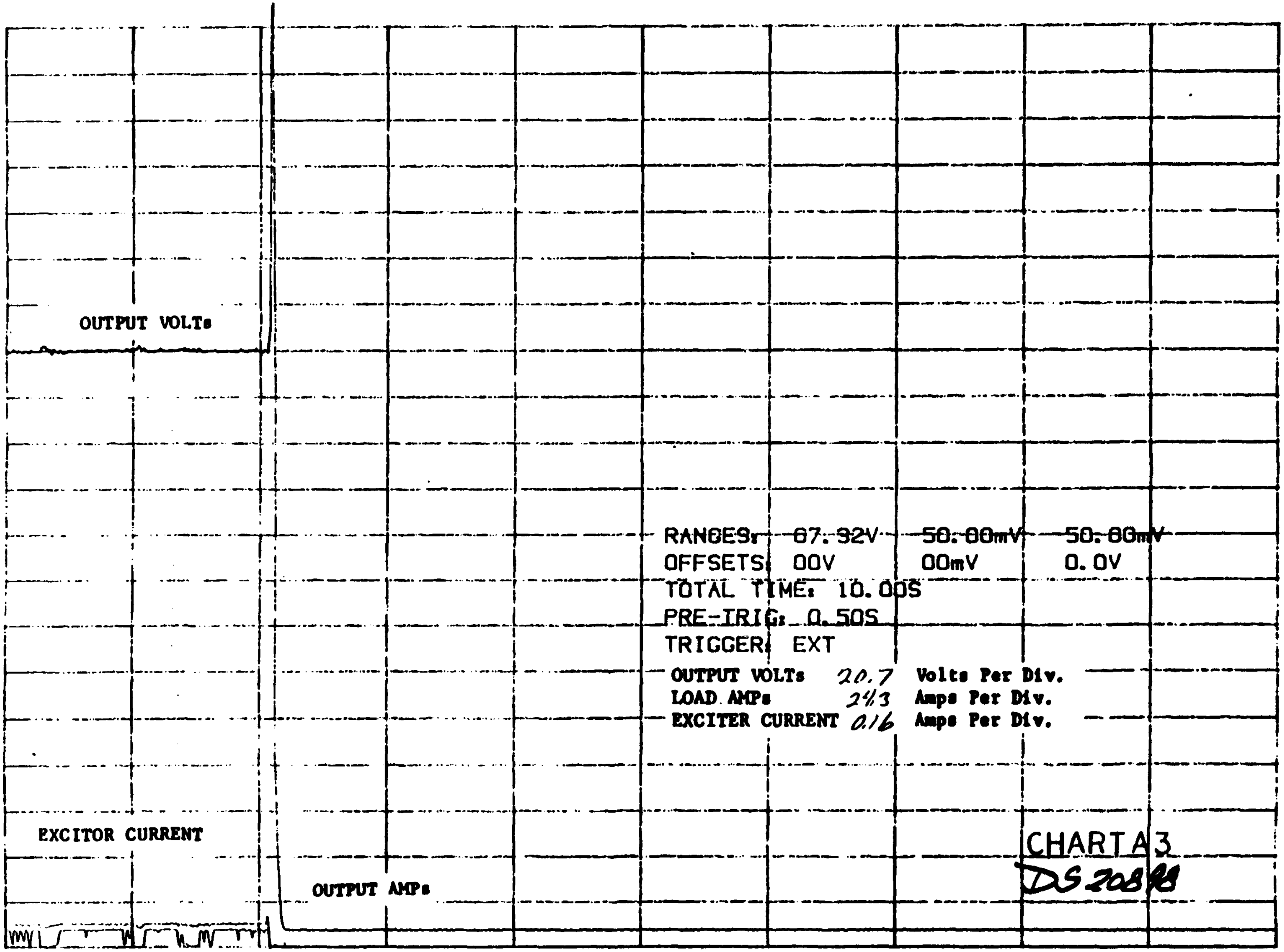

OUTPUT VOLTs
SWITCH CHATTER
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 41.4 Volts Per Div.
LOAD AMPs 15.6 Amps Per Div.
EXCITER CURRENT 0.32 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART A1
DS 20898

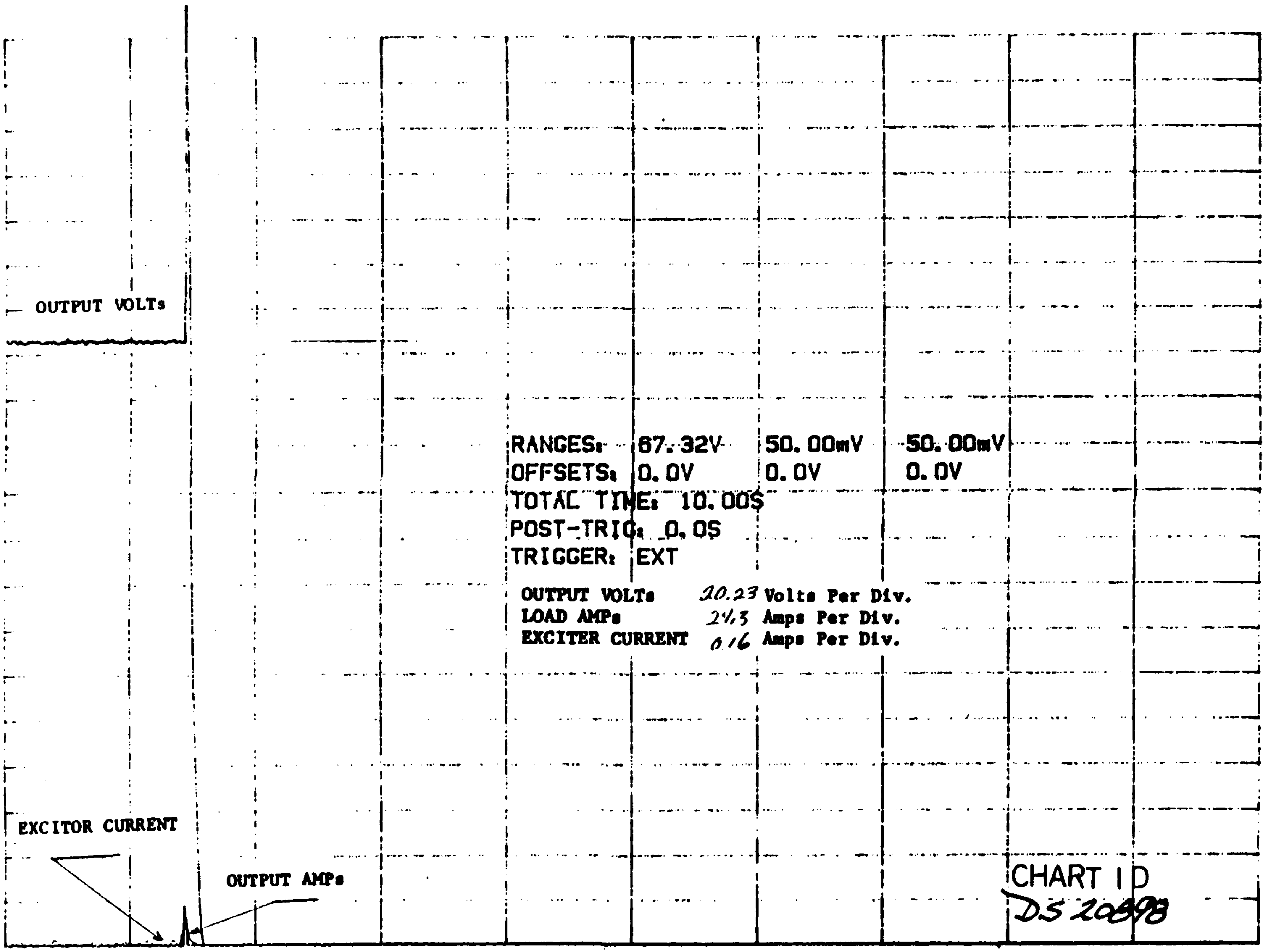

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 10.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART 1B
DS 2084B

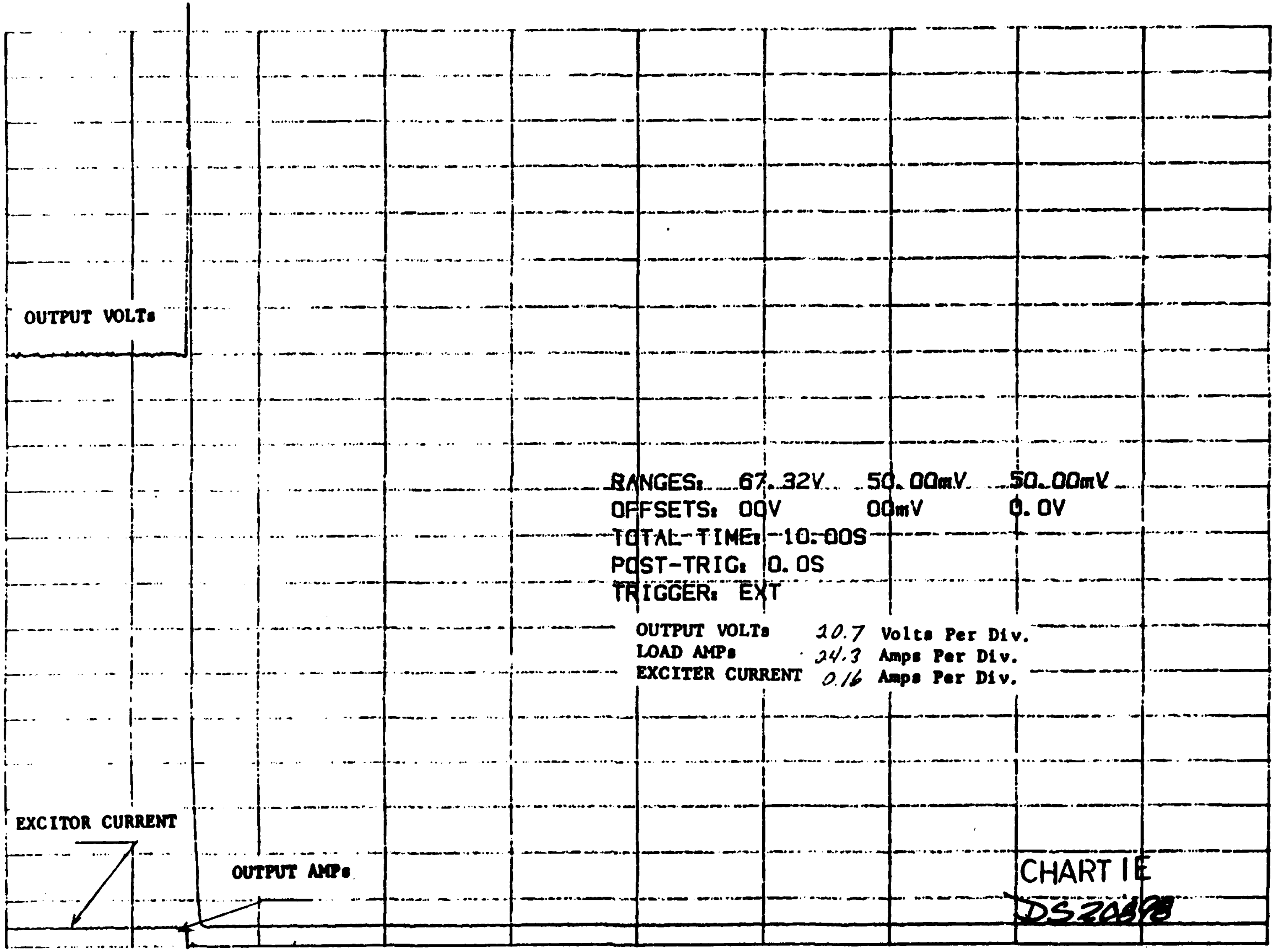

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART IC
DS 208198



OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART A2
DS 20898


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART A3
DS 208


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART ID
DS 20898


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 10.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
EXCITOR CURRENT
OUTPUT AMPs
CHART IE
DS20898

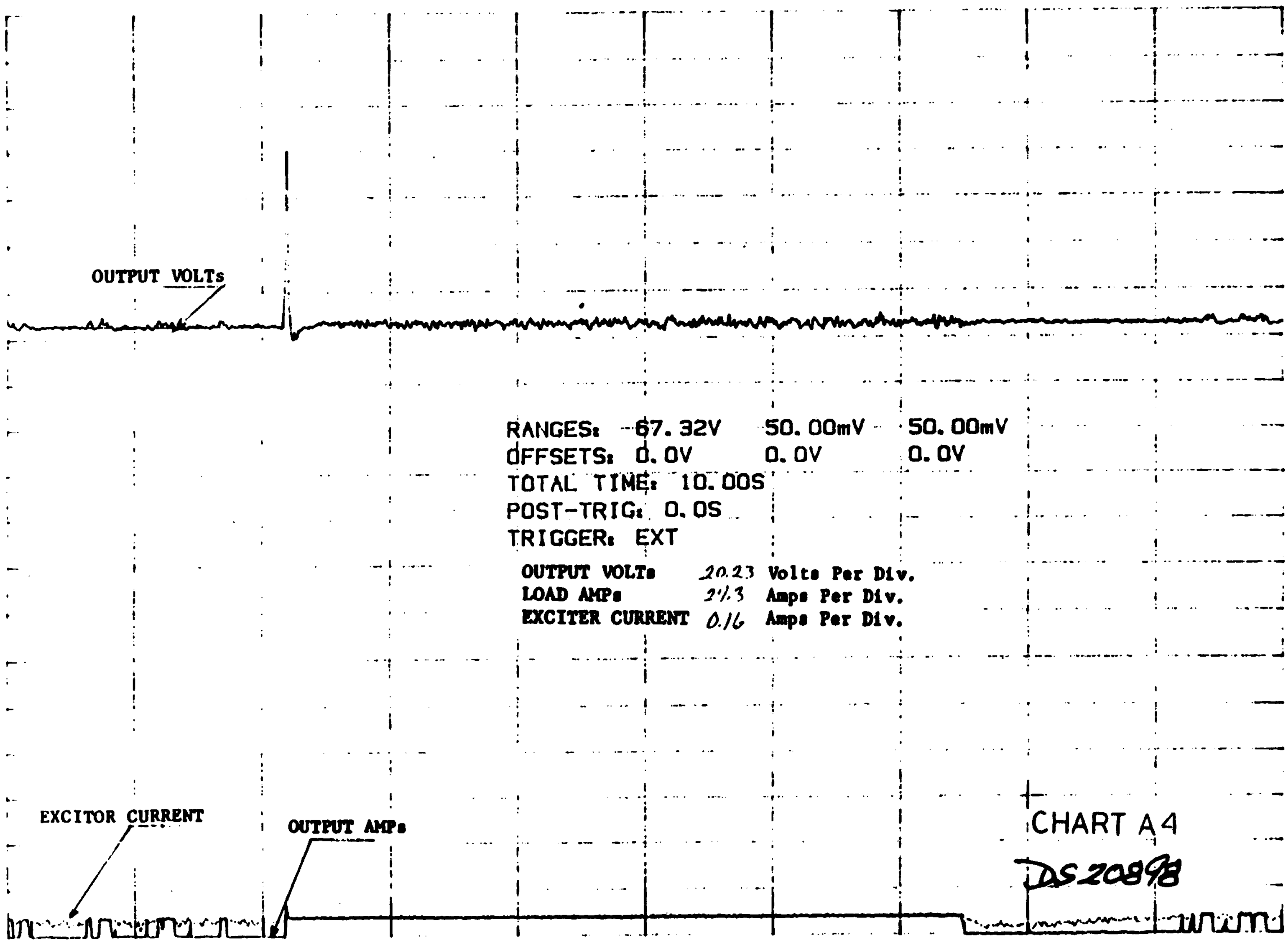
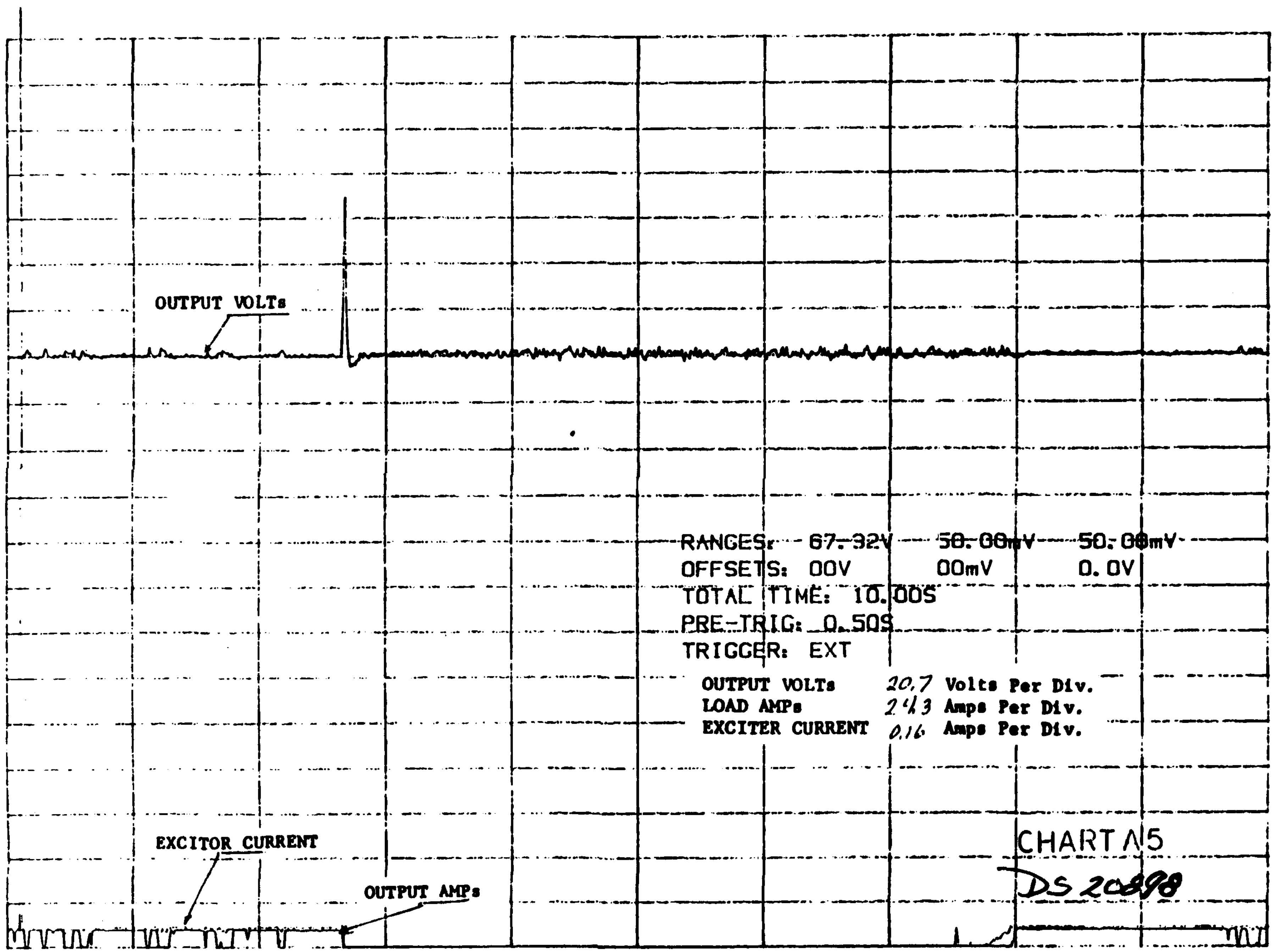
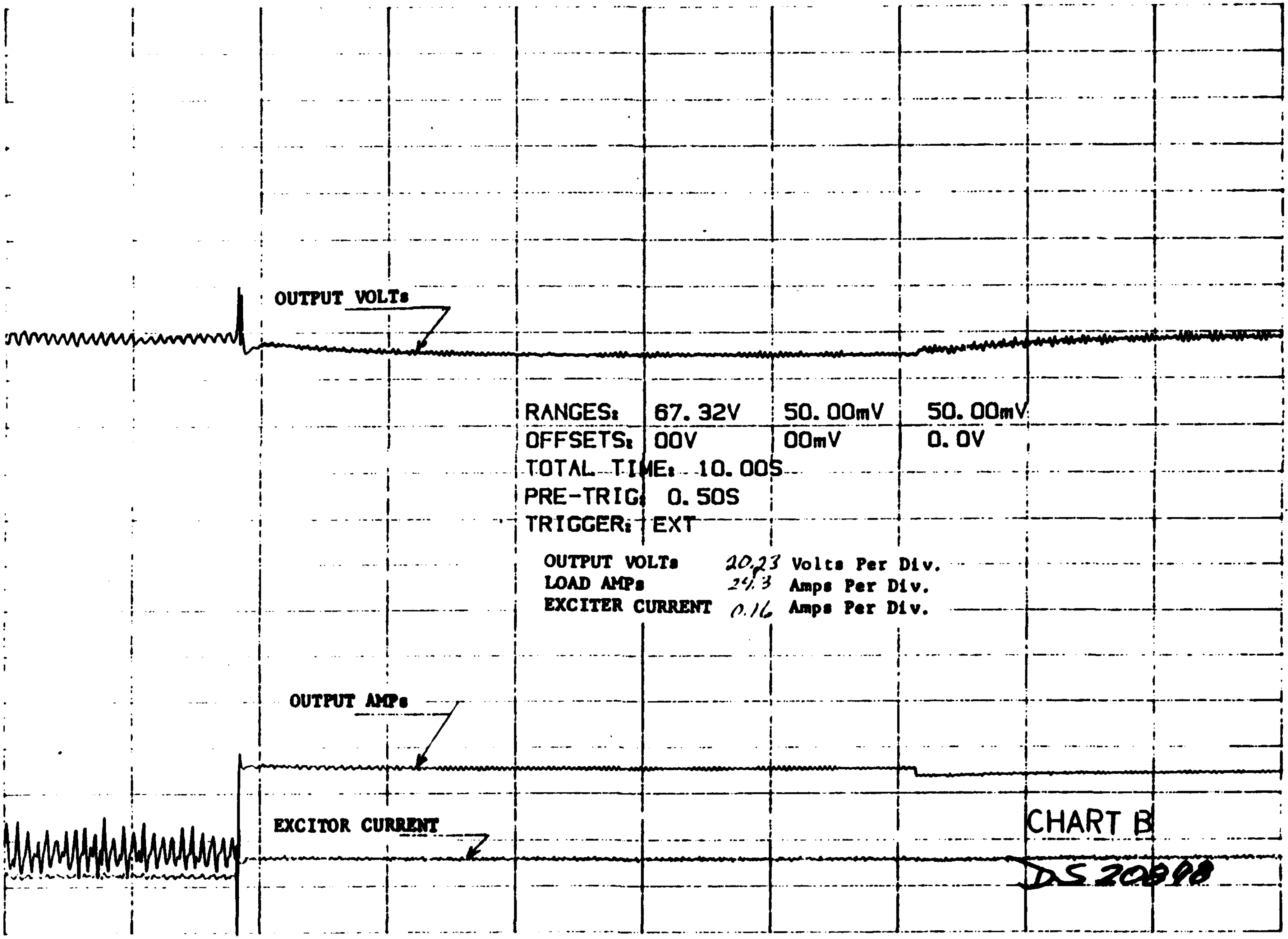


CHART A4

DS20898


OUTPUT VOLTs
EXCITOR CURRENT
OUTPUT AMPs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART A5
DS 20898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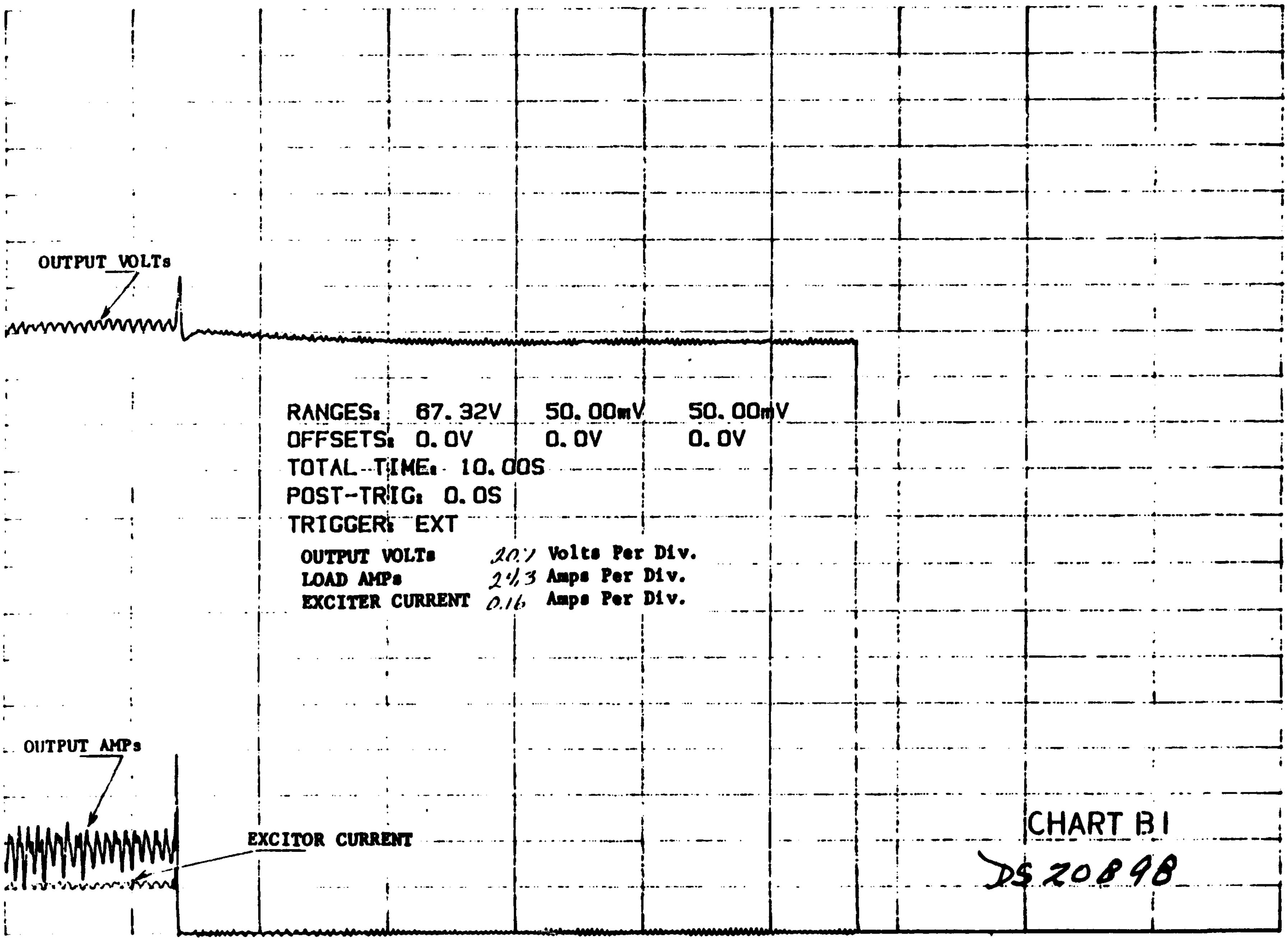
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART B
DS 20898


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL-TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART B1
DS 20898

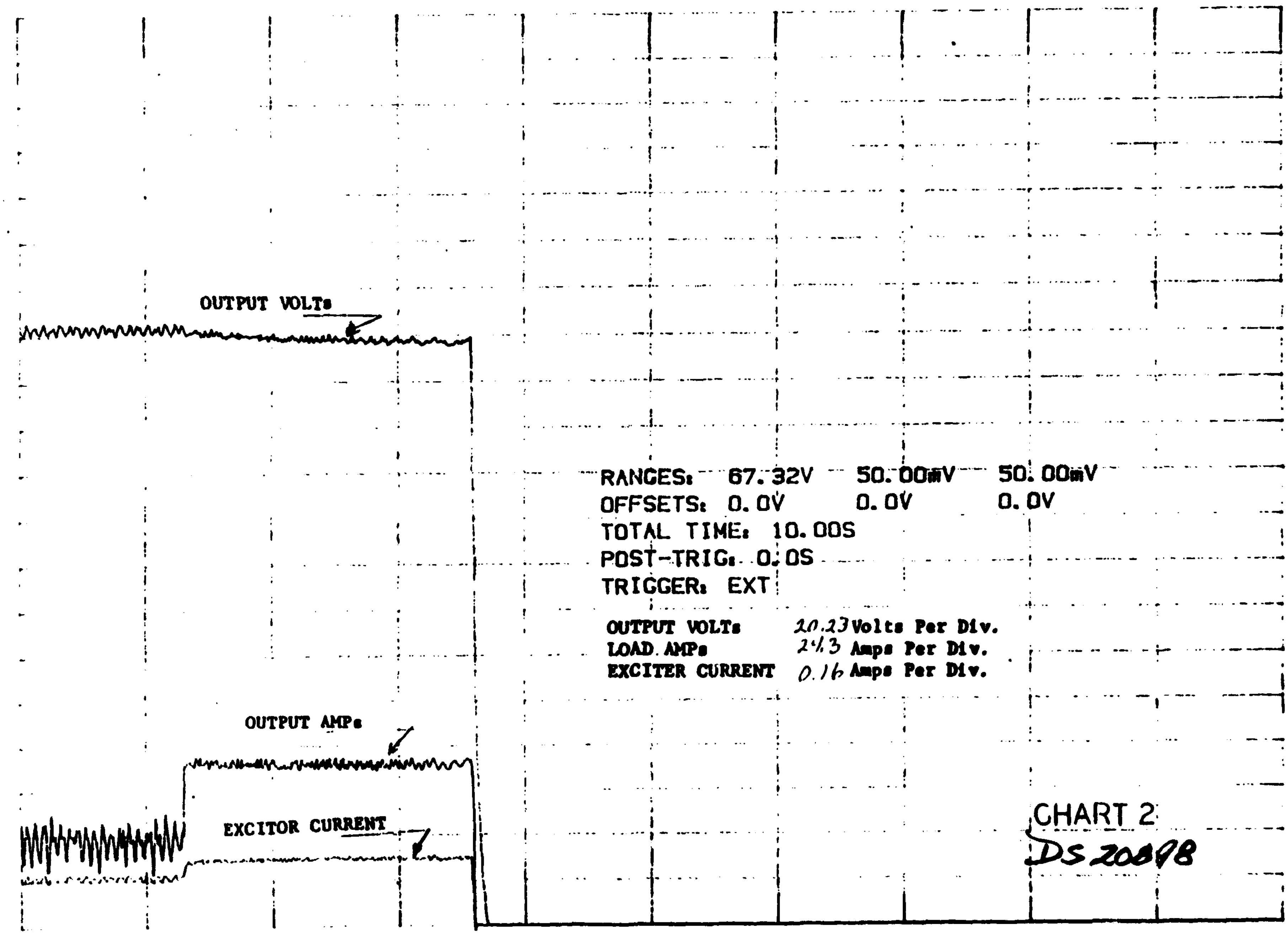
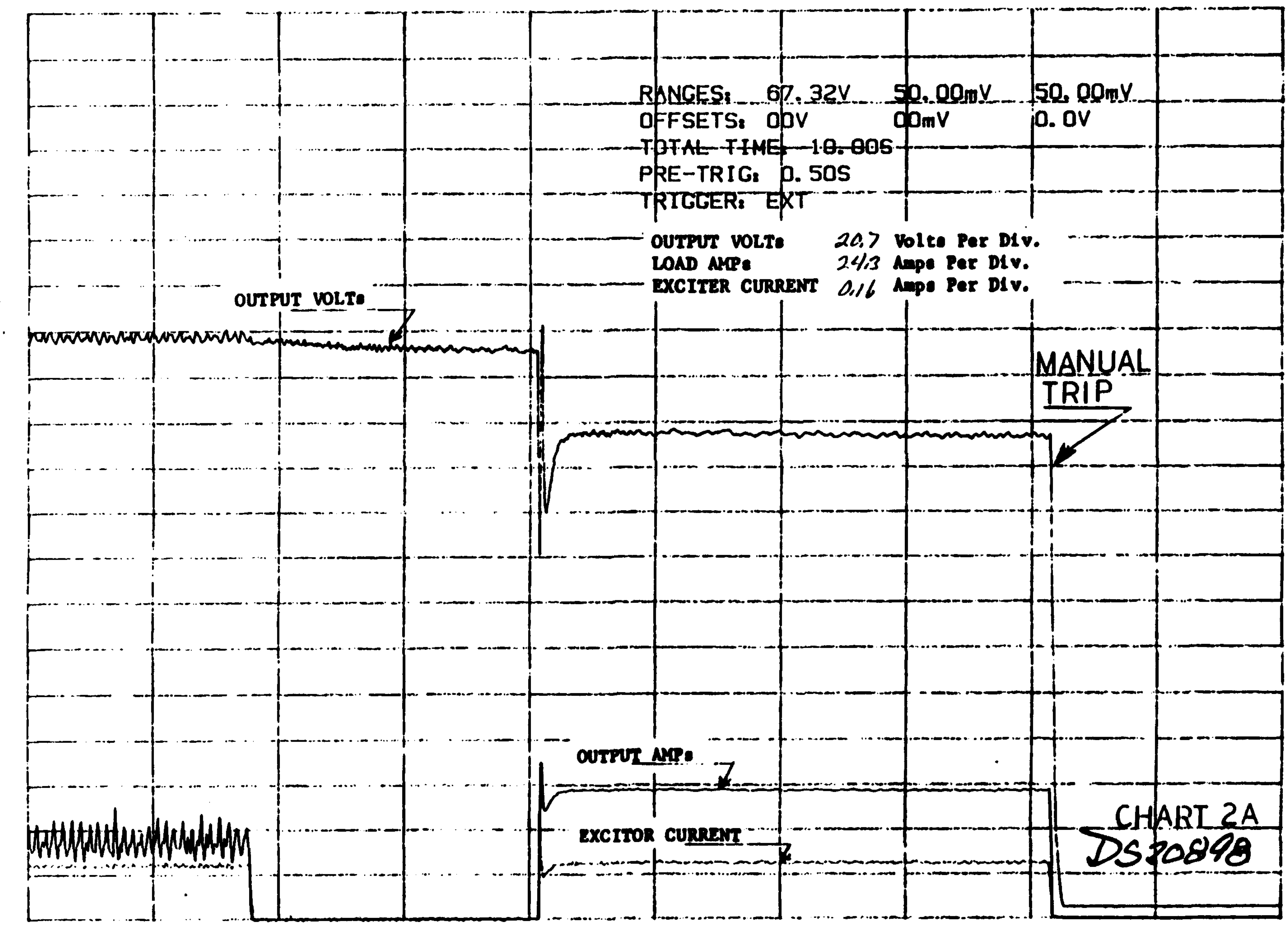
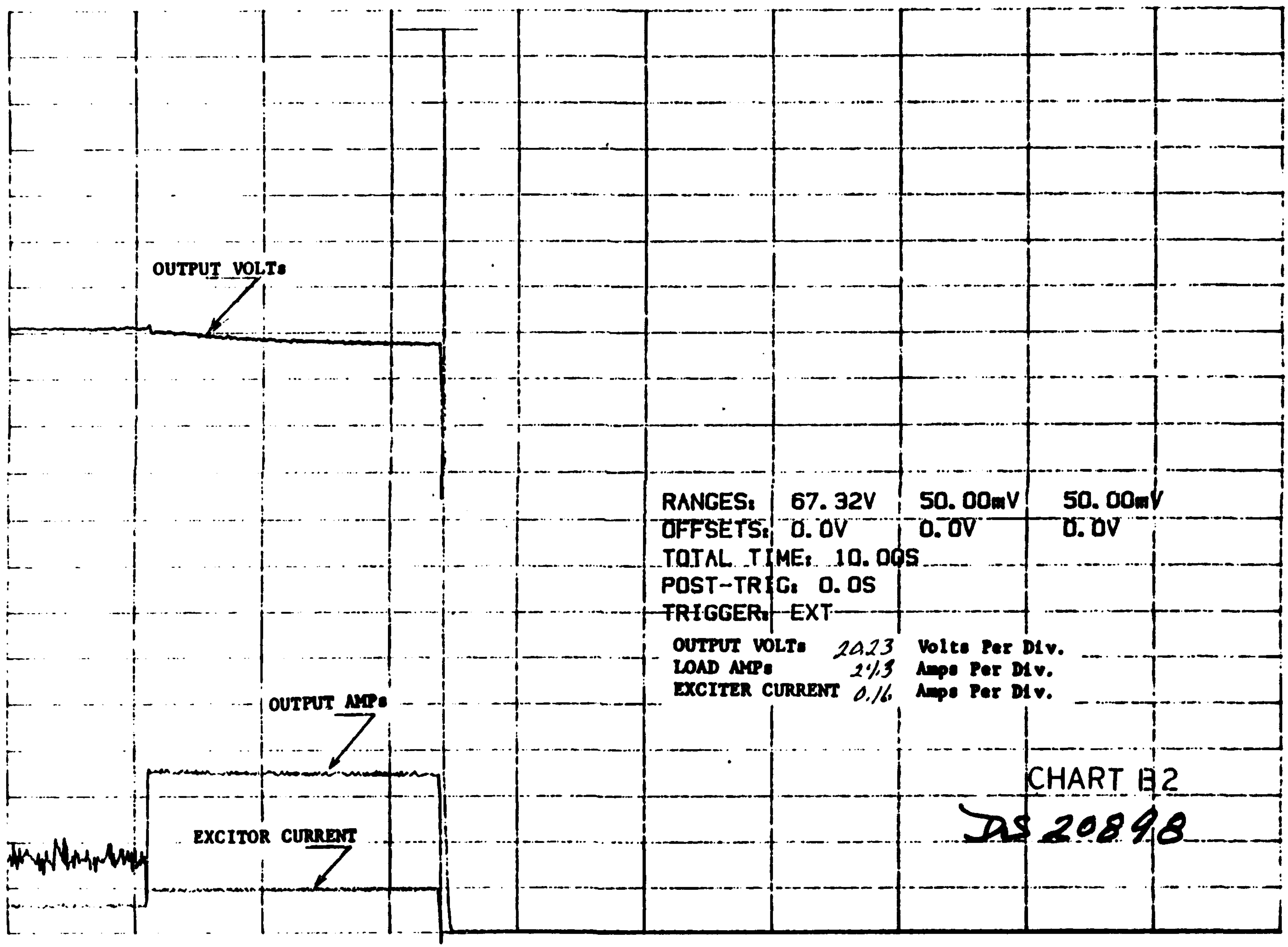
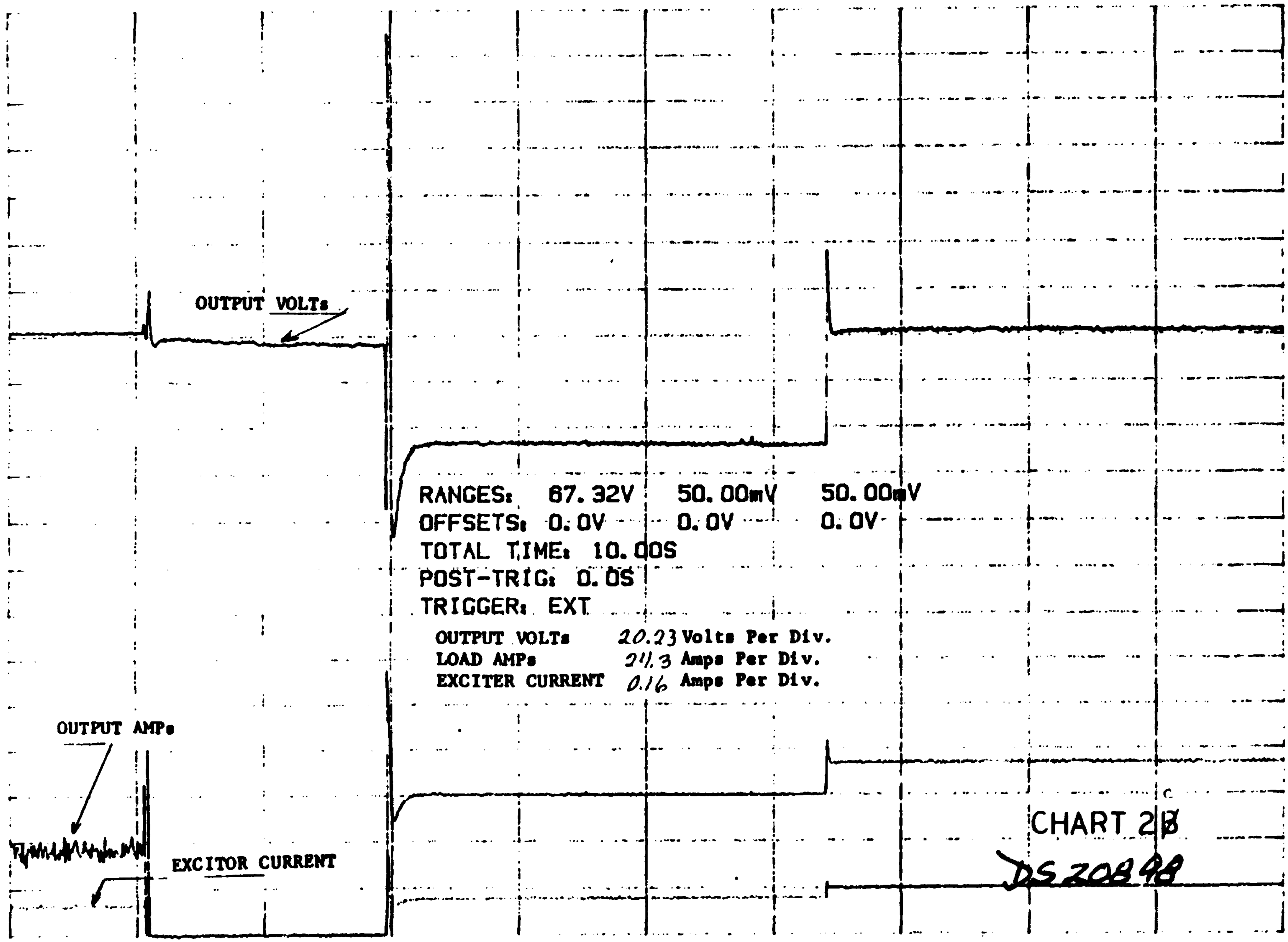


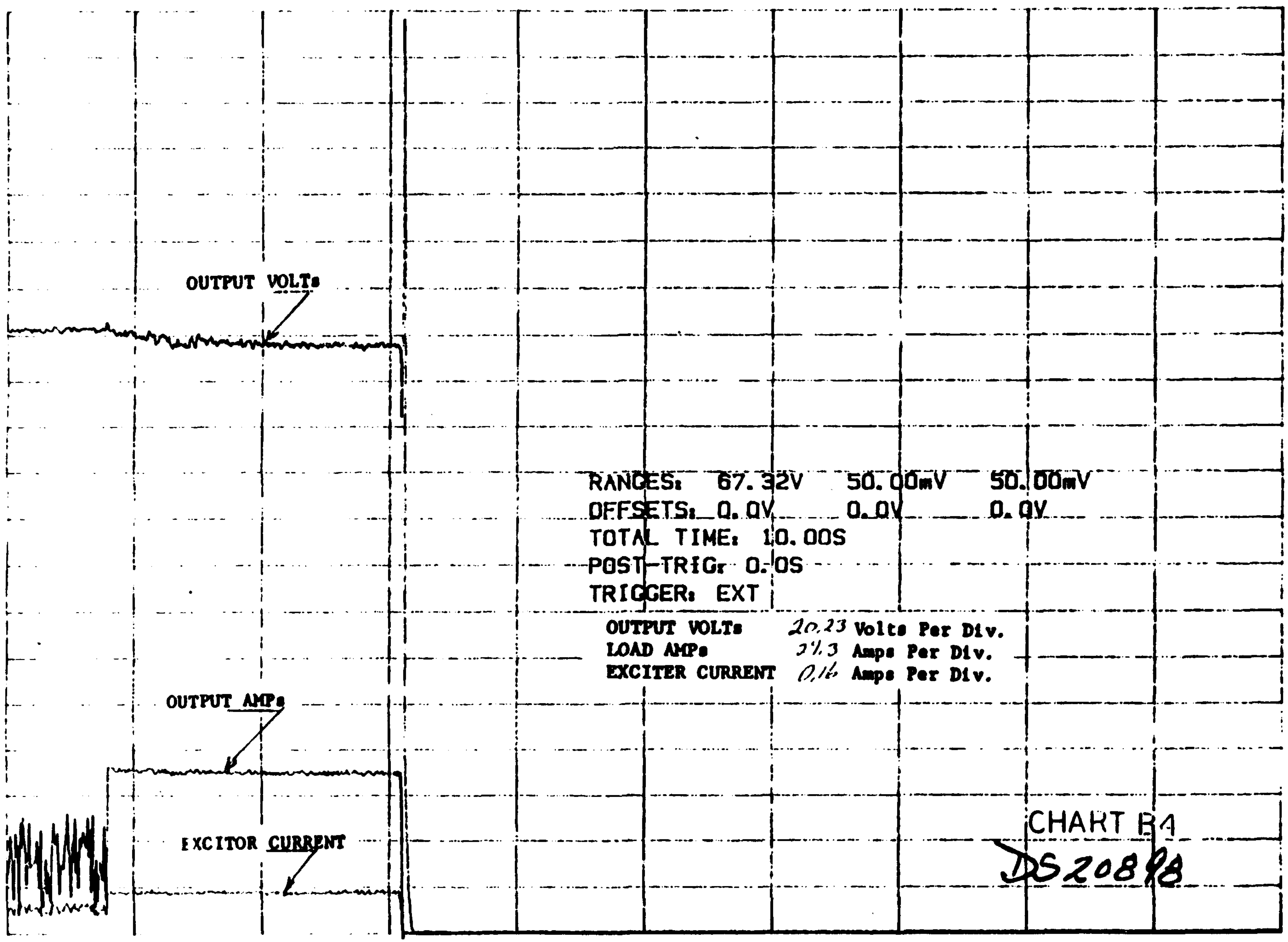
CHART 2
DS 20898



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT VOLTs
MANUAL TRIP
OUTPUT AMPs
EXCITOR CURRENT
CHART 2A
DS20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 2.13 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART B2
DS 20898


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 2B
DS20898



OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
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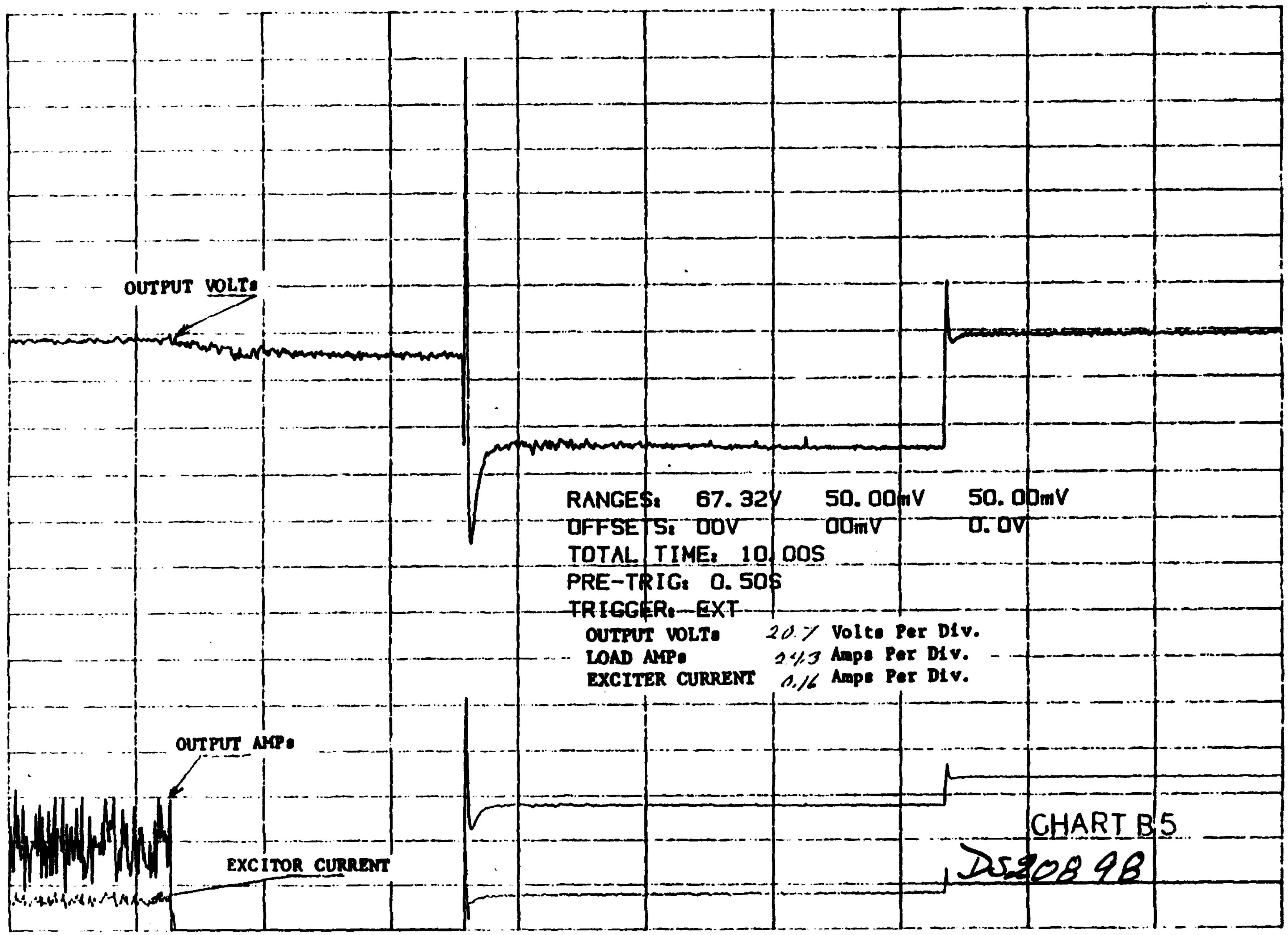
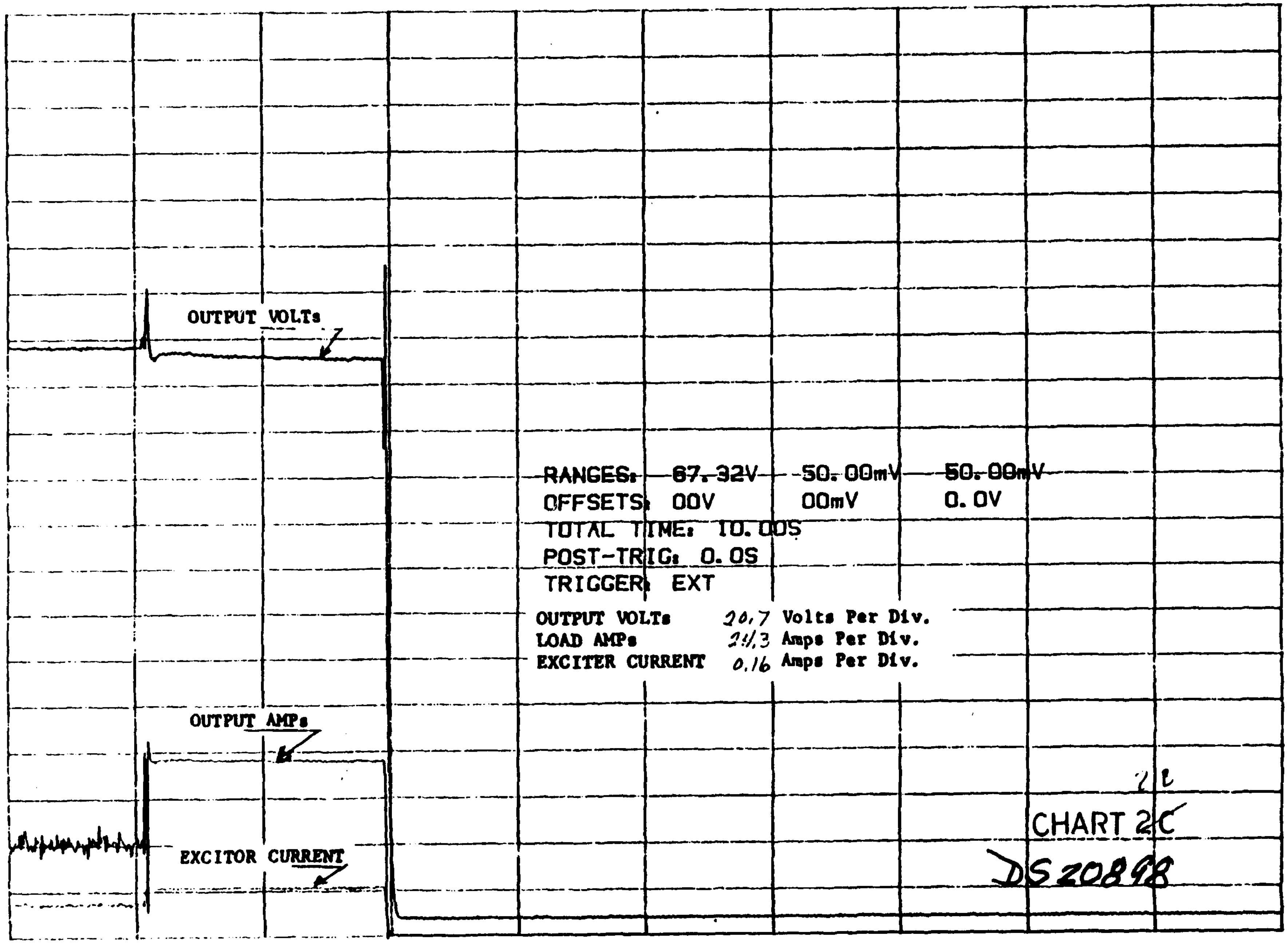
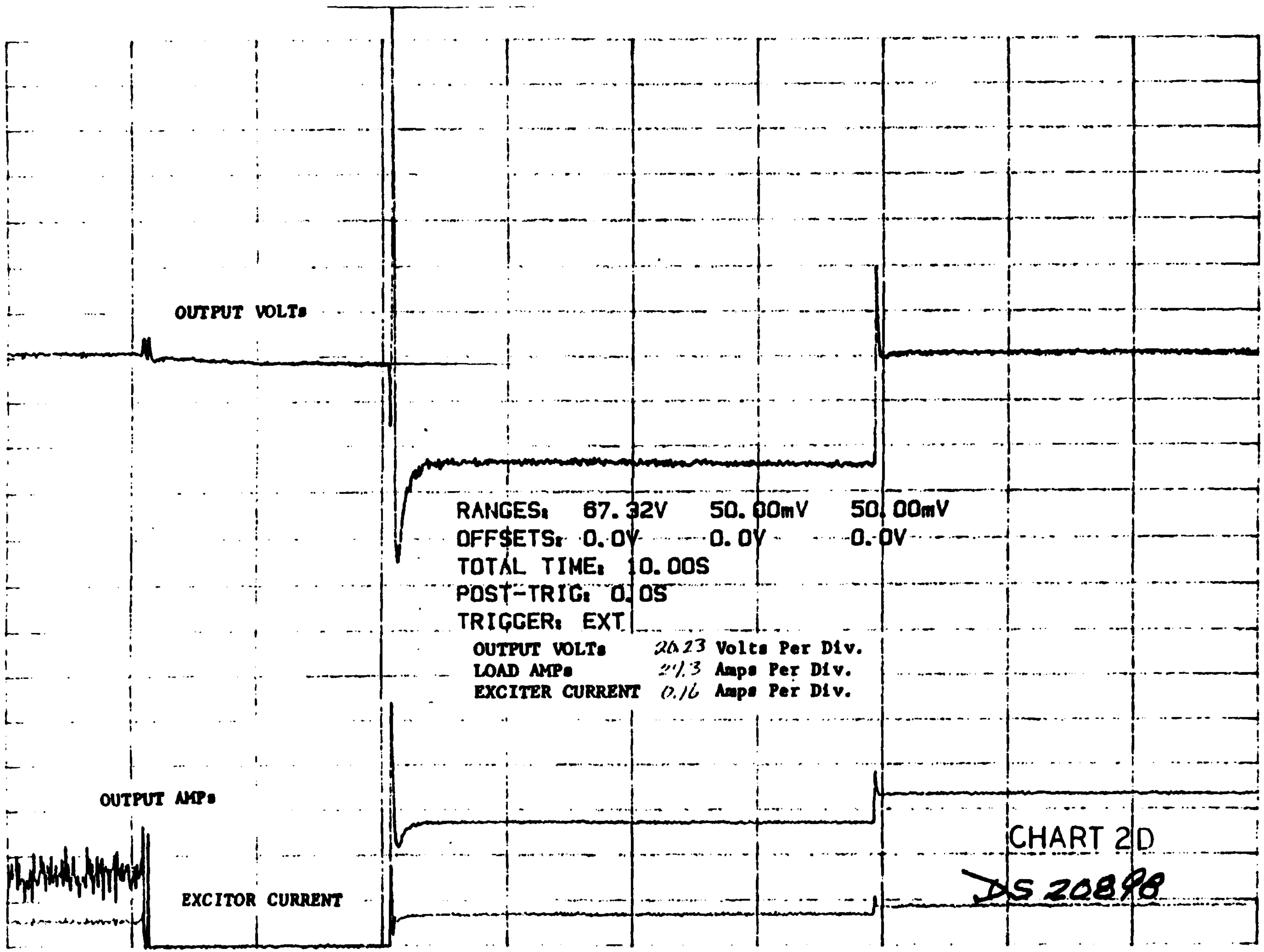
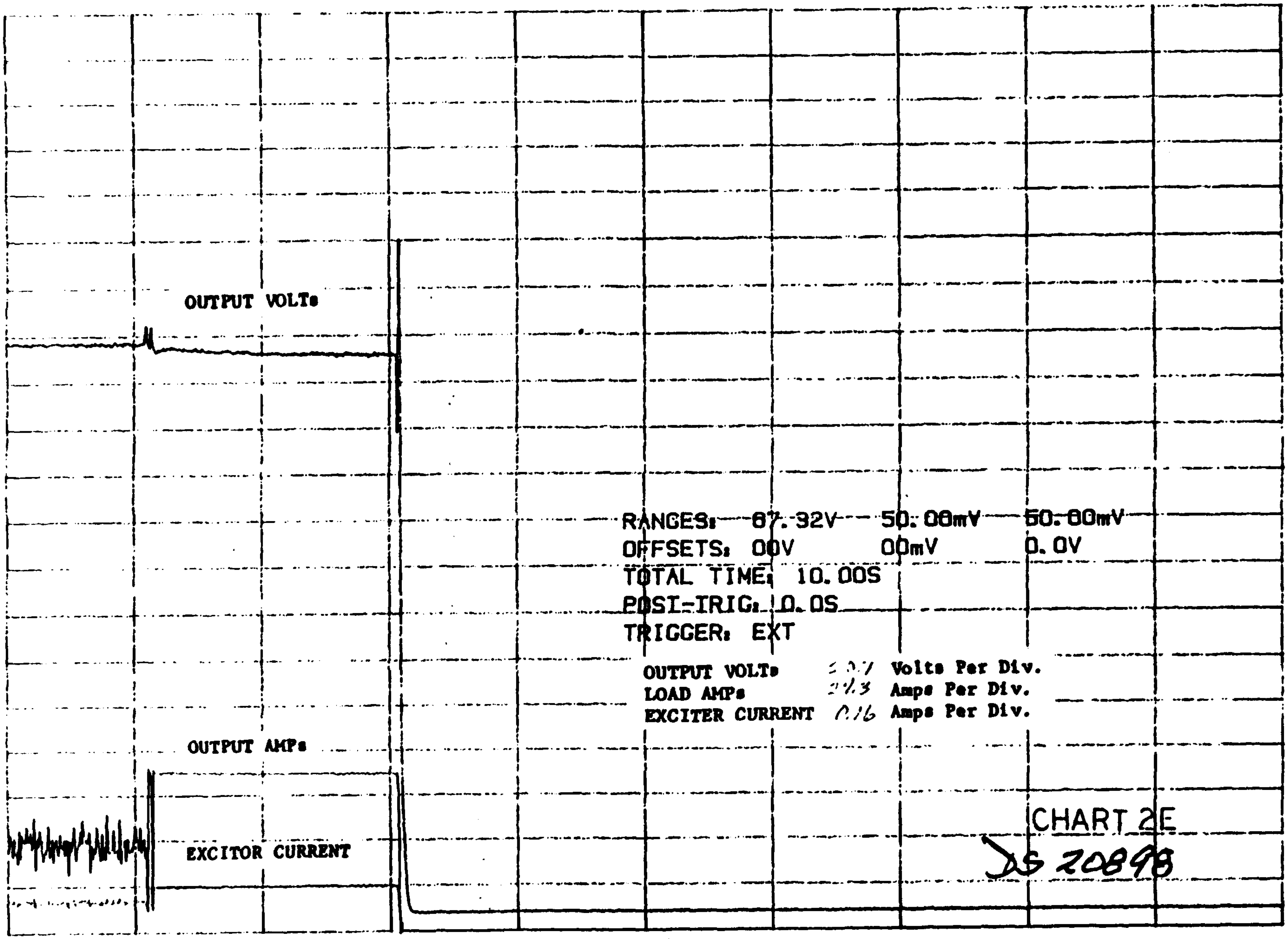
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 27.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART B4
DS20898

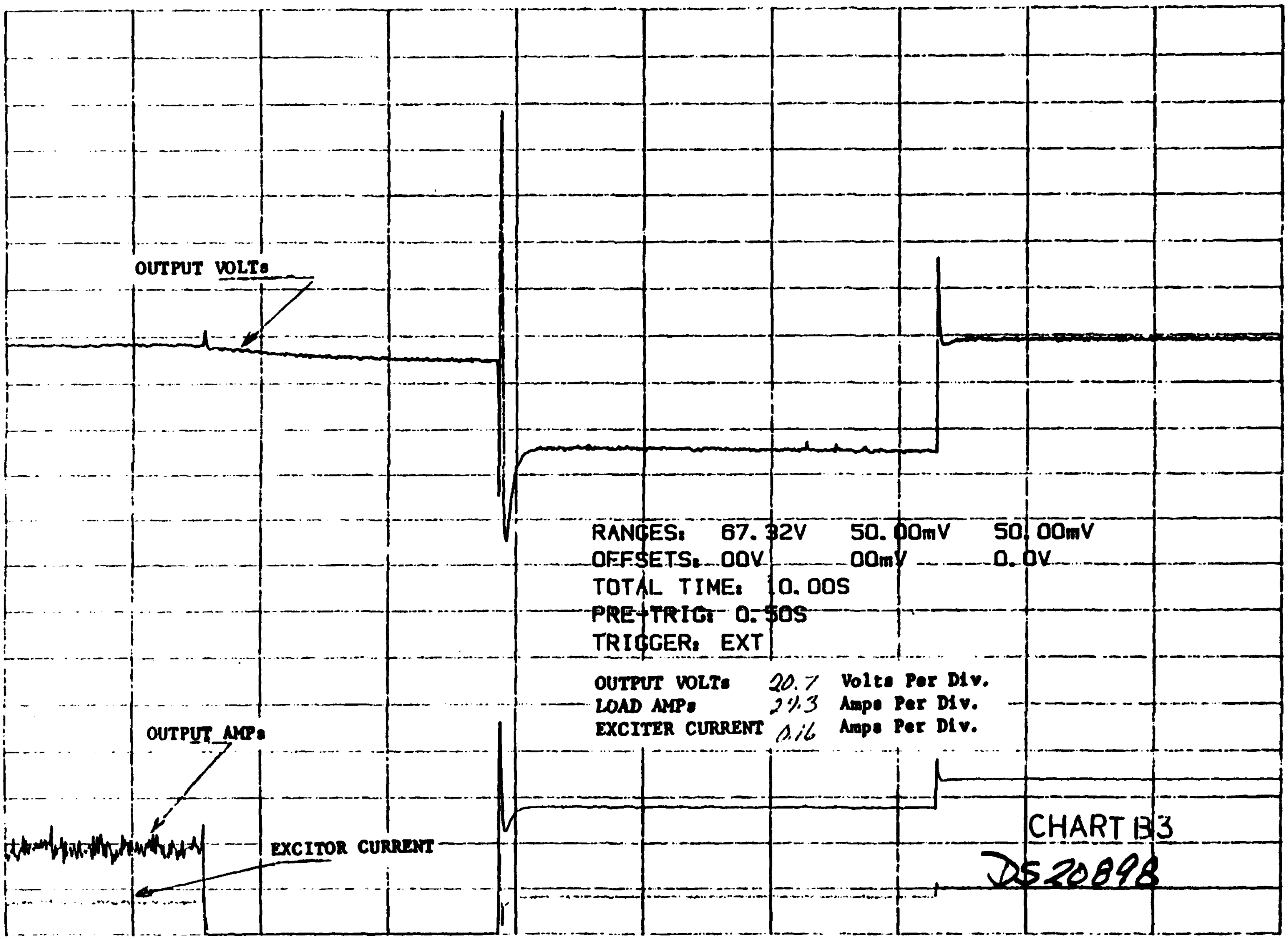

OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART B5
DS208 9B



OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART 2C
DS 20898


OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 26.23 Volts Per Div.
LOAD AMPs 27.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 2D
DS 20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POSI-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs Volts Per Div.
LOAD AMPs Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART 2E
DS 20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART B3
DS20898

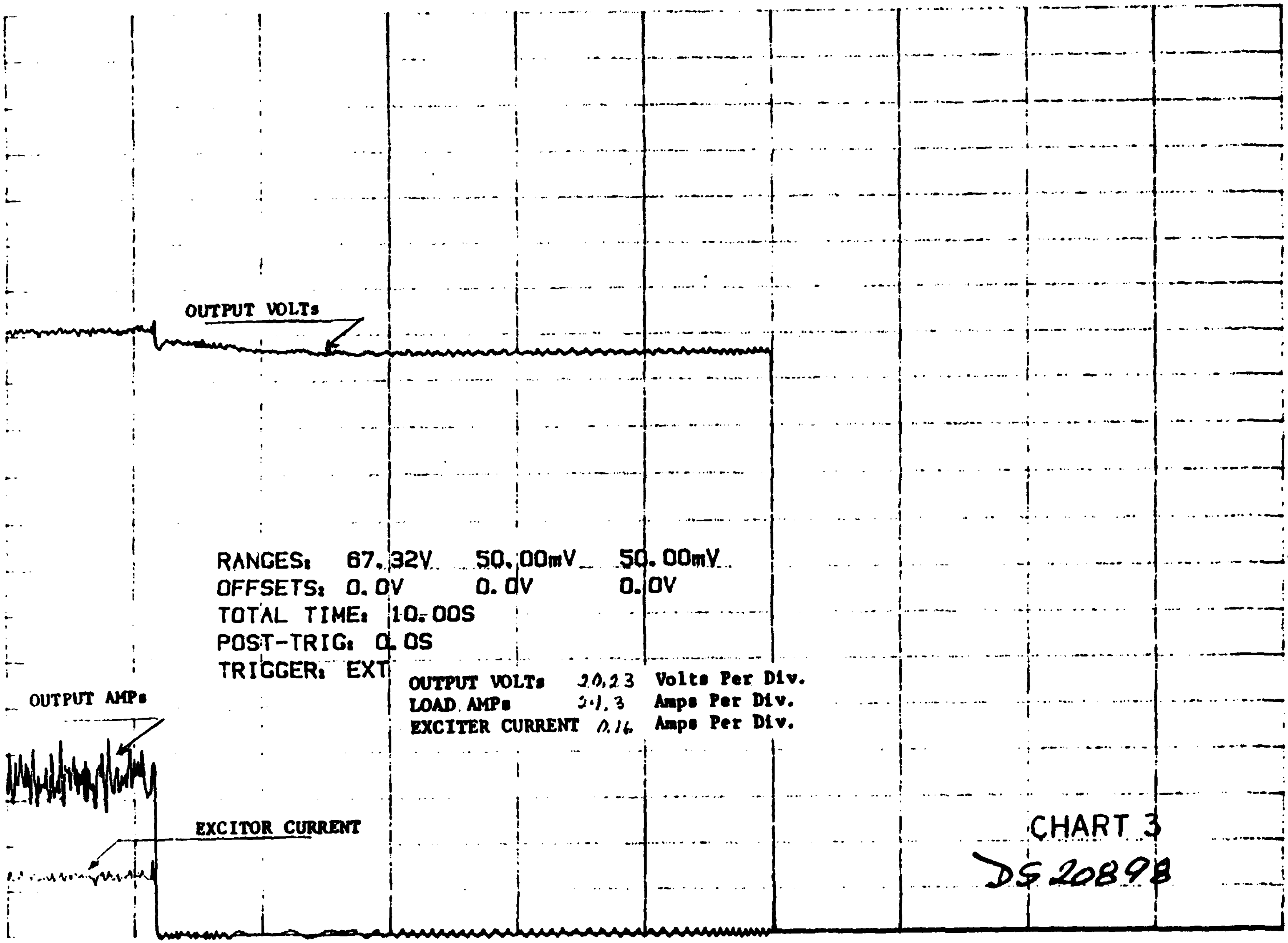
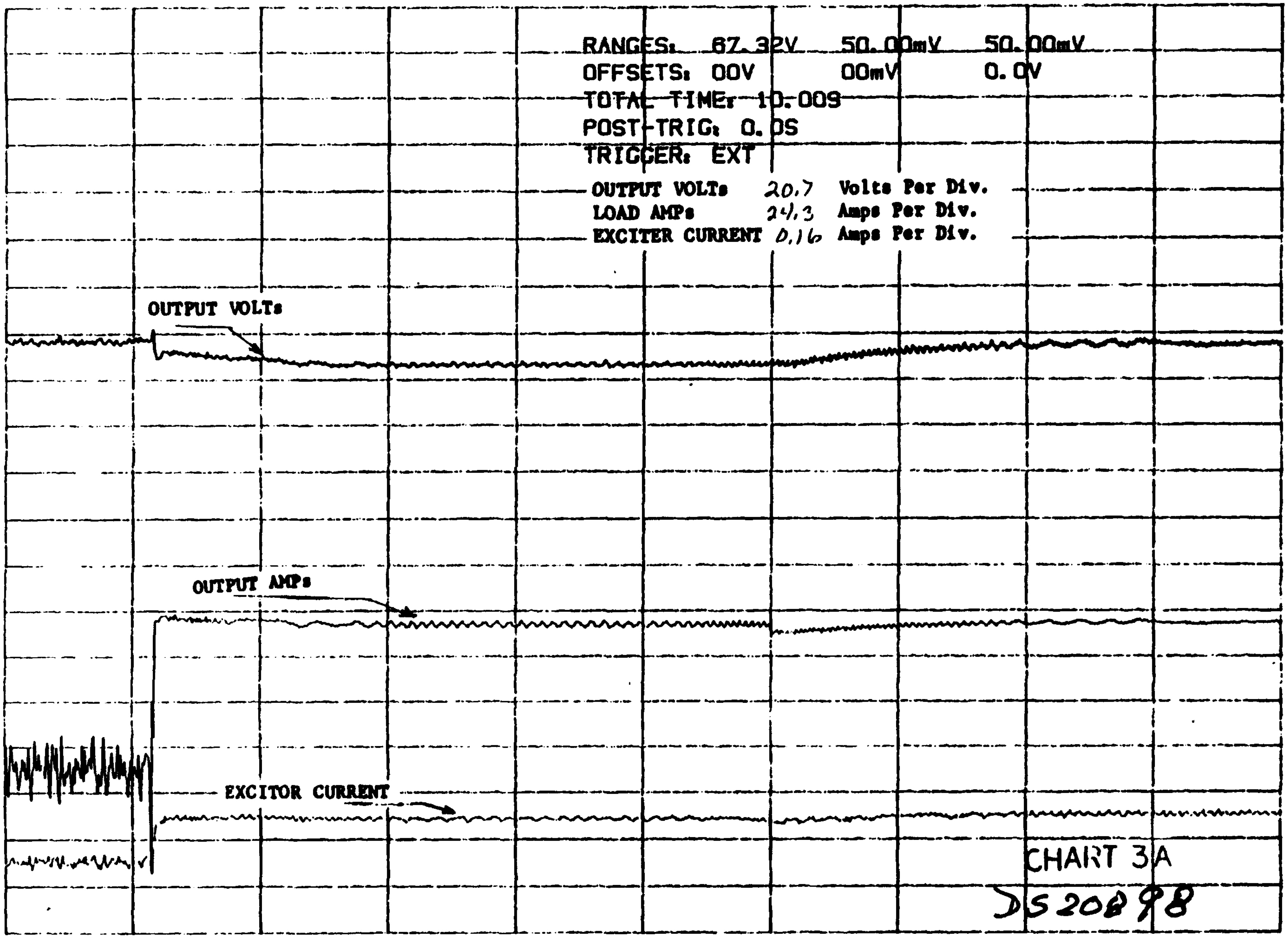
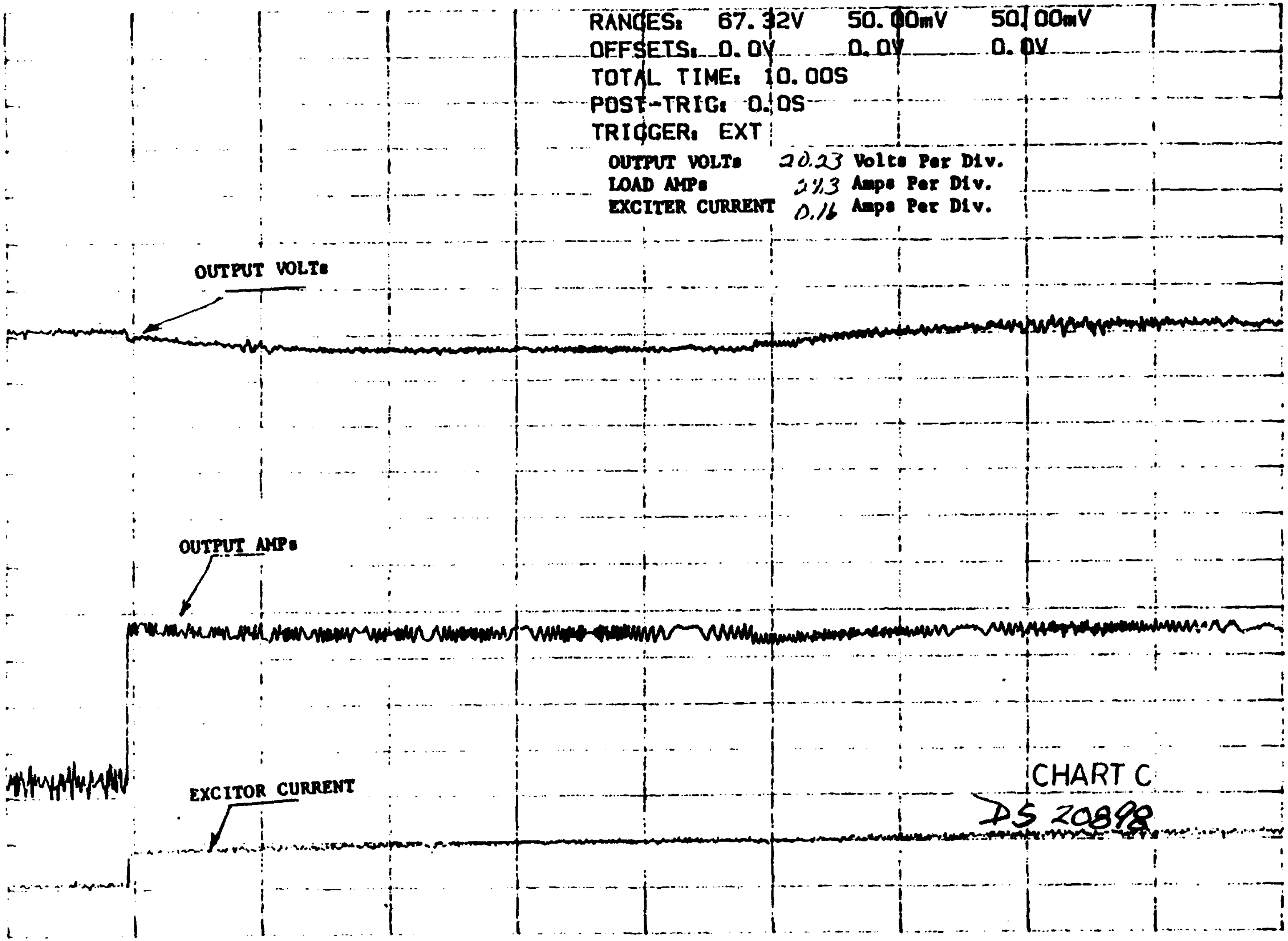
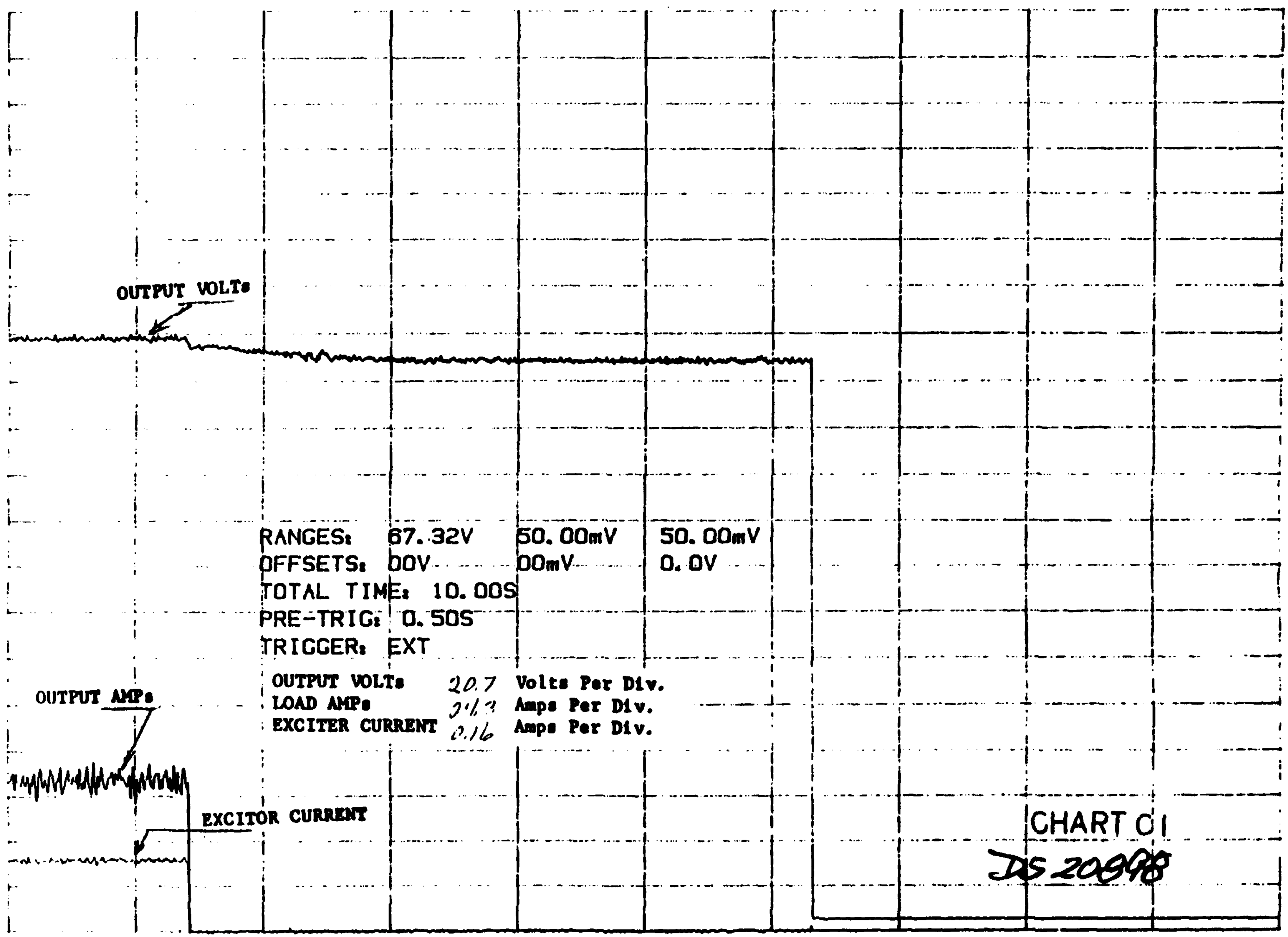


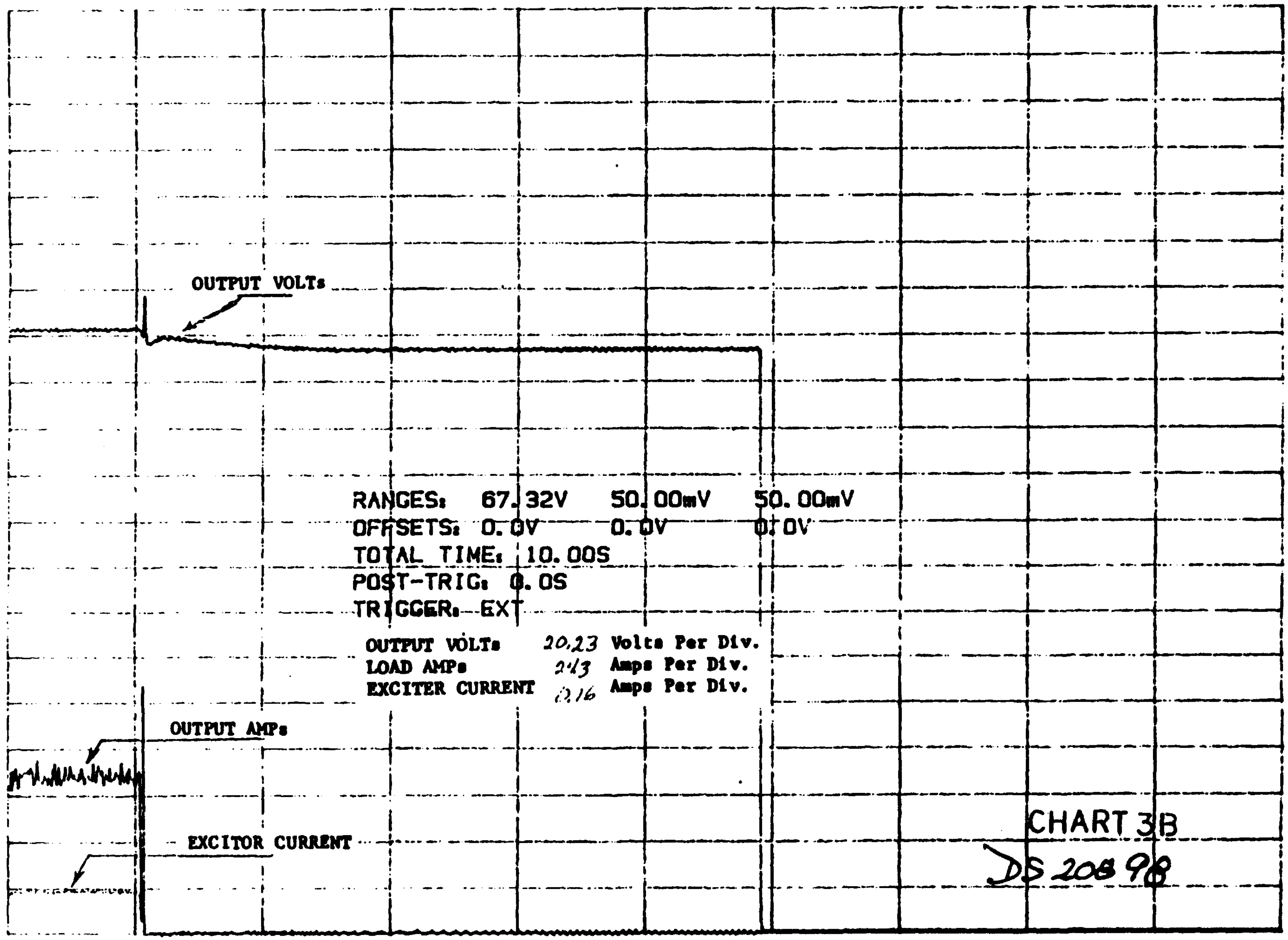
CHART 3

DS 20898


RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
CHART 3A
DS20898


RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
CHART C
DS 20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART C1
DS 20998



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 3B
DS 20898

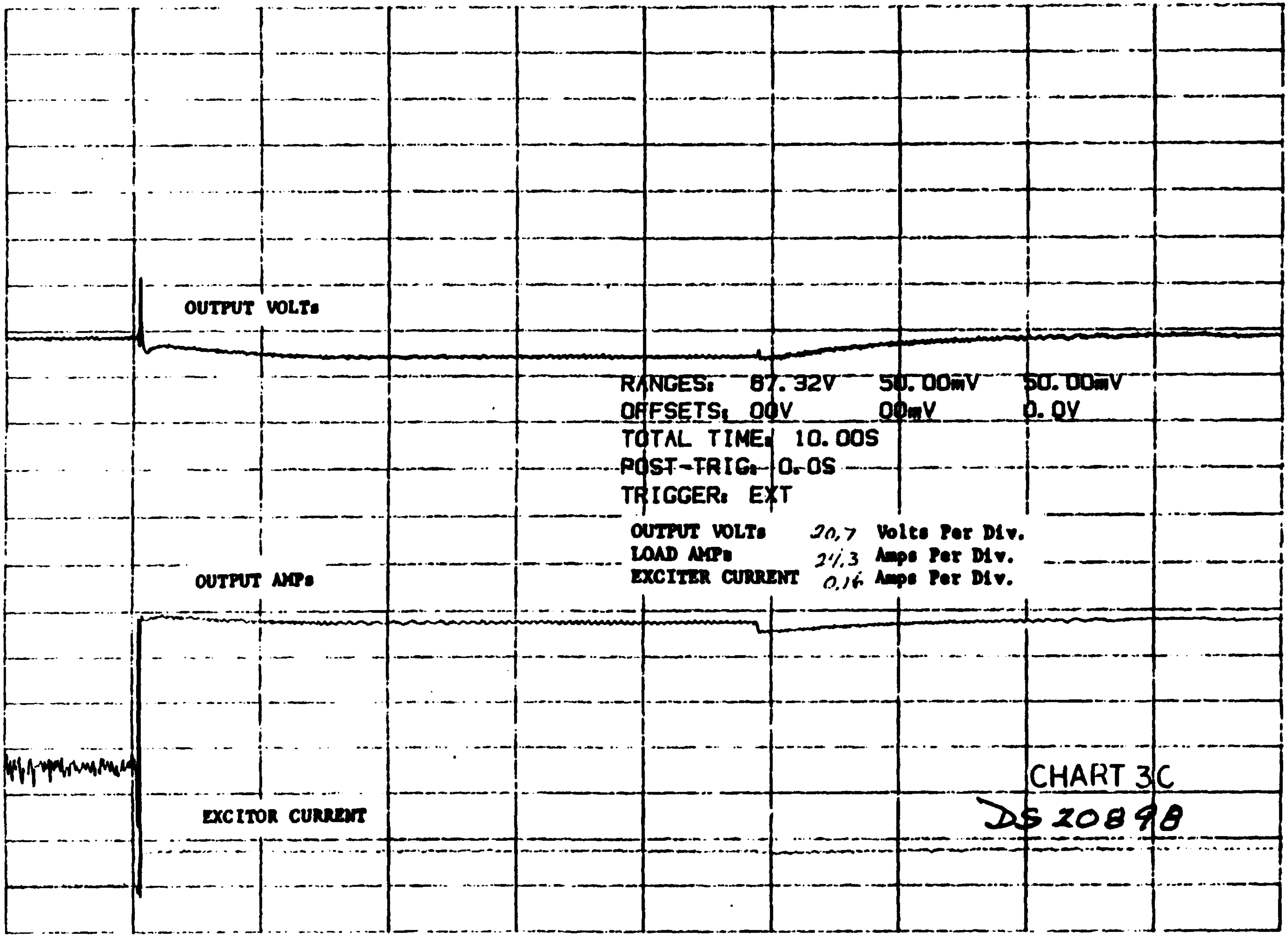
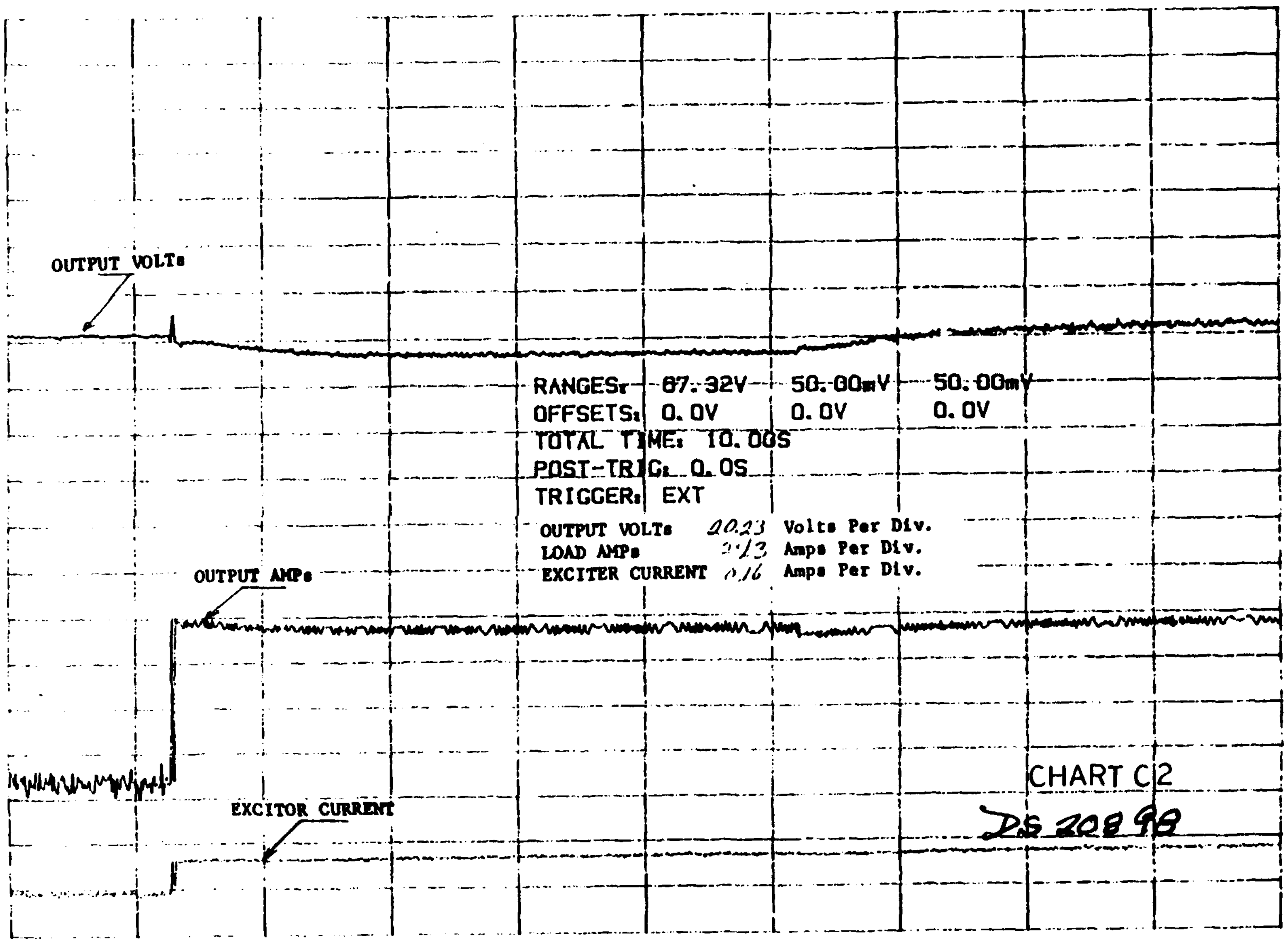
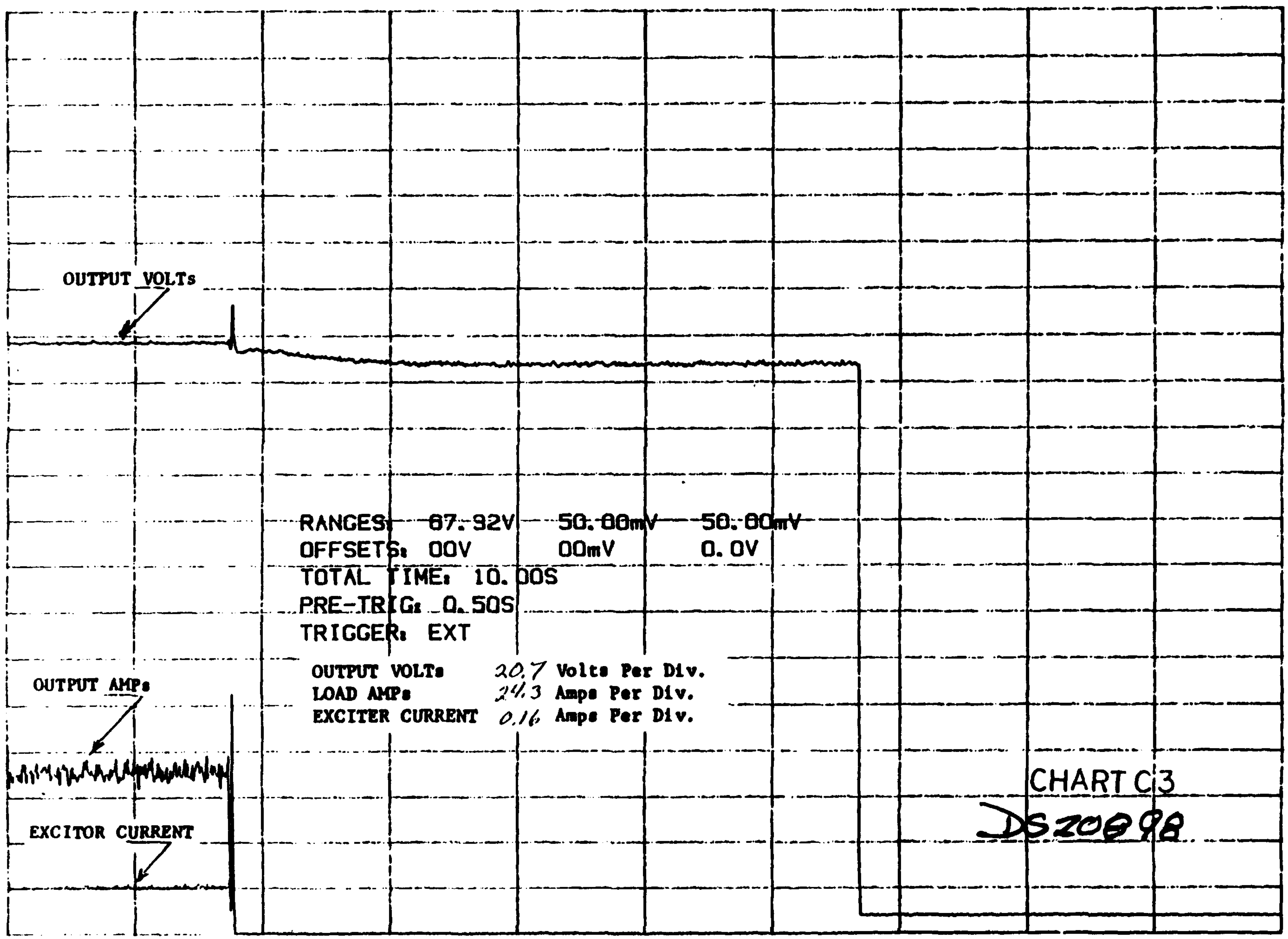
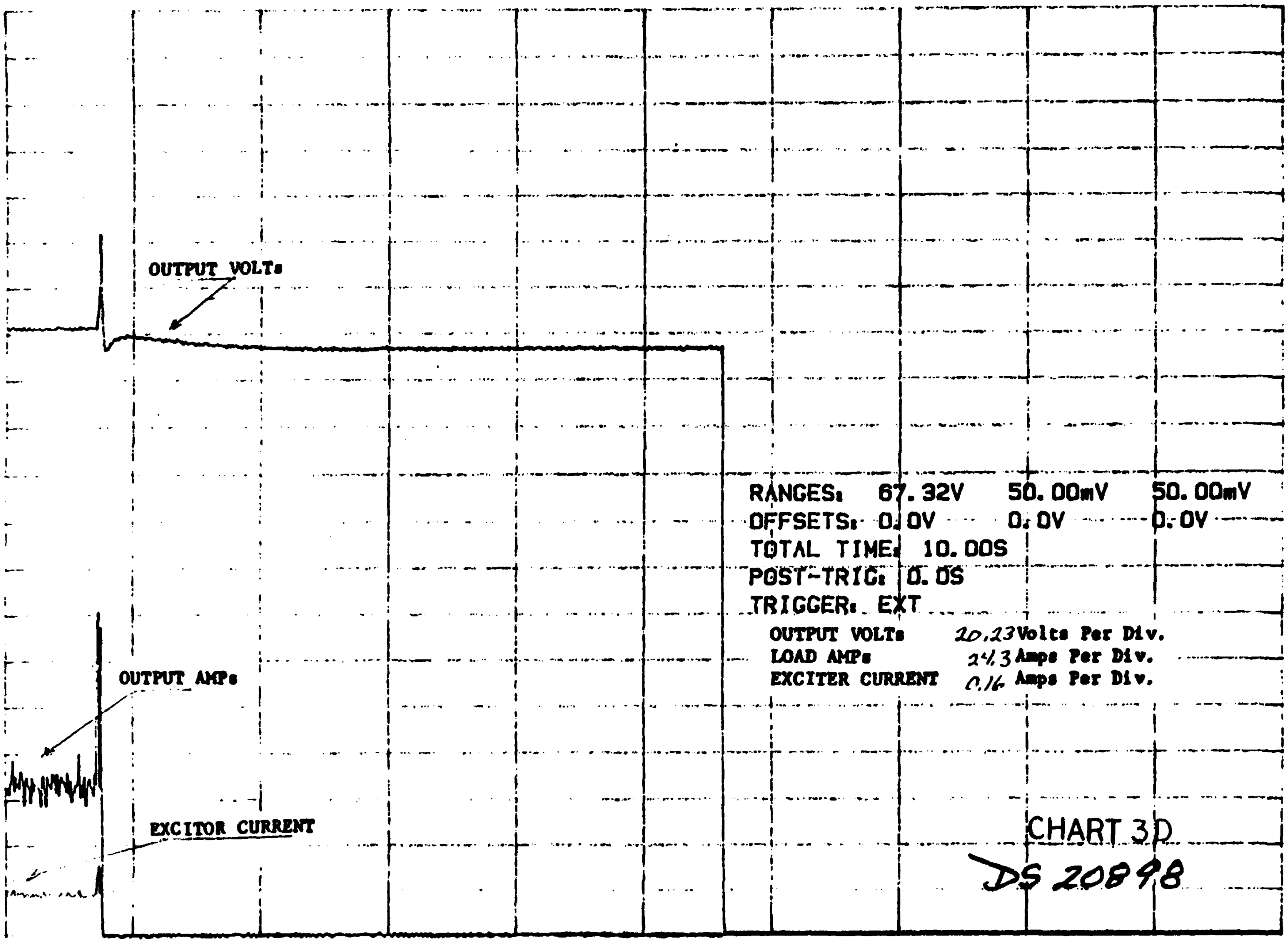


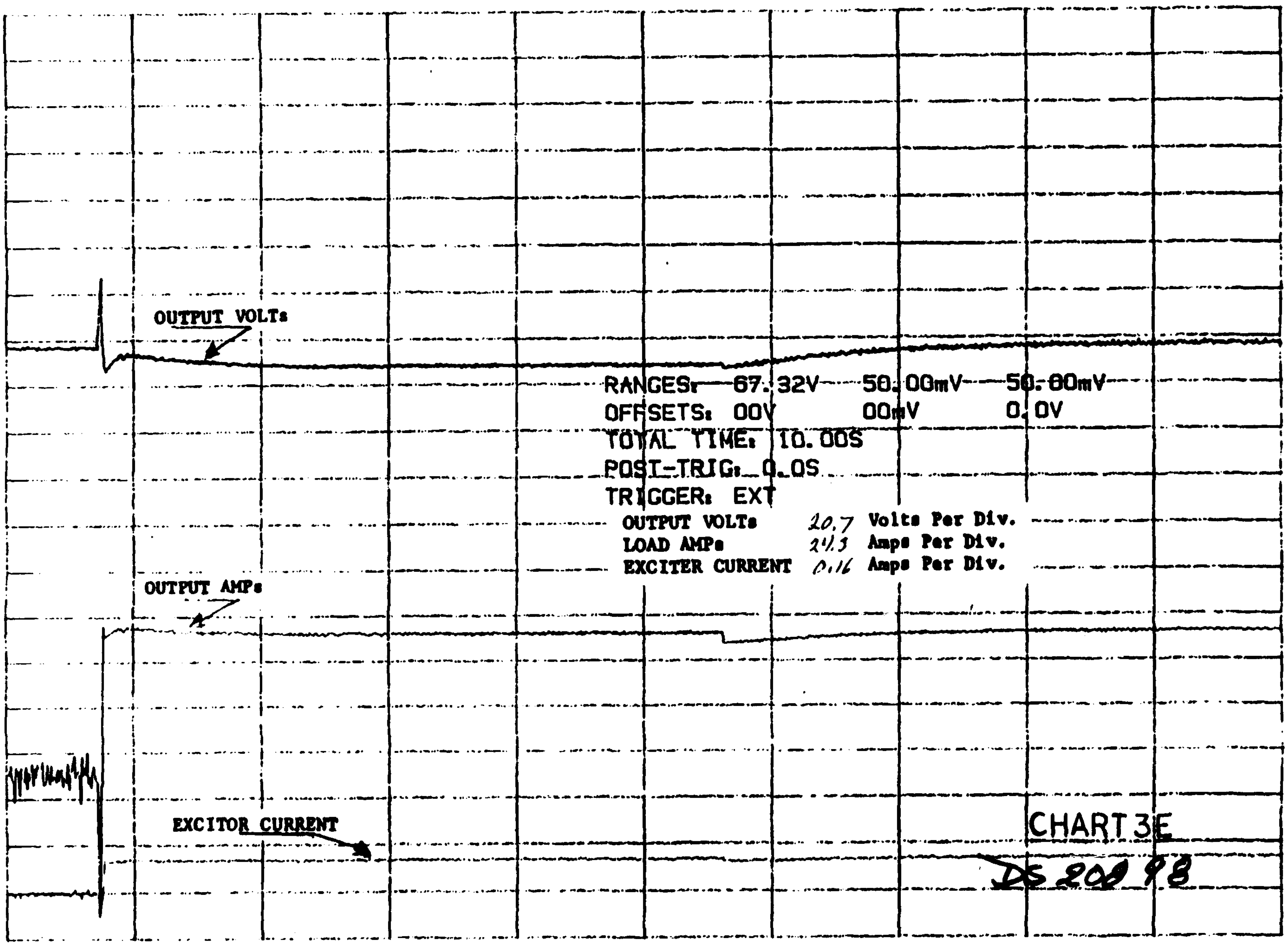
CHART 3C

DS 20898

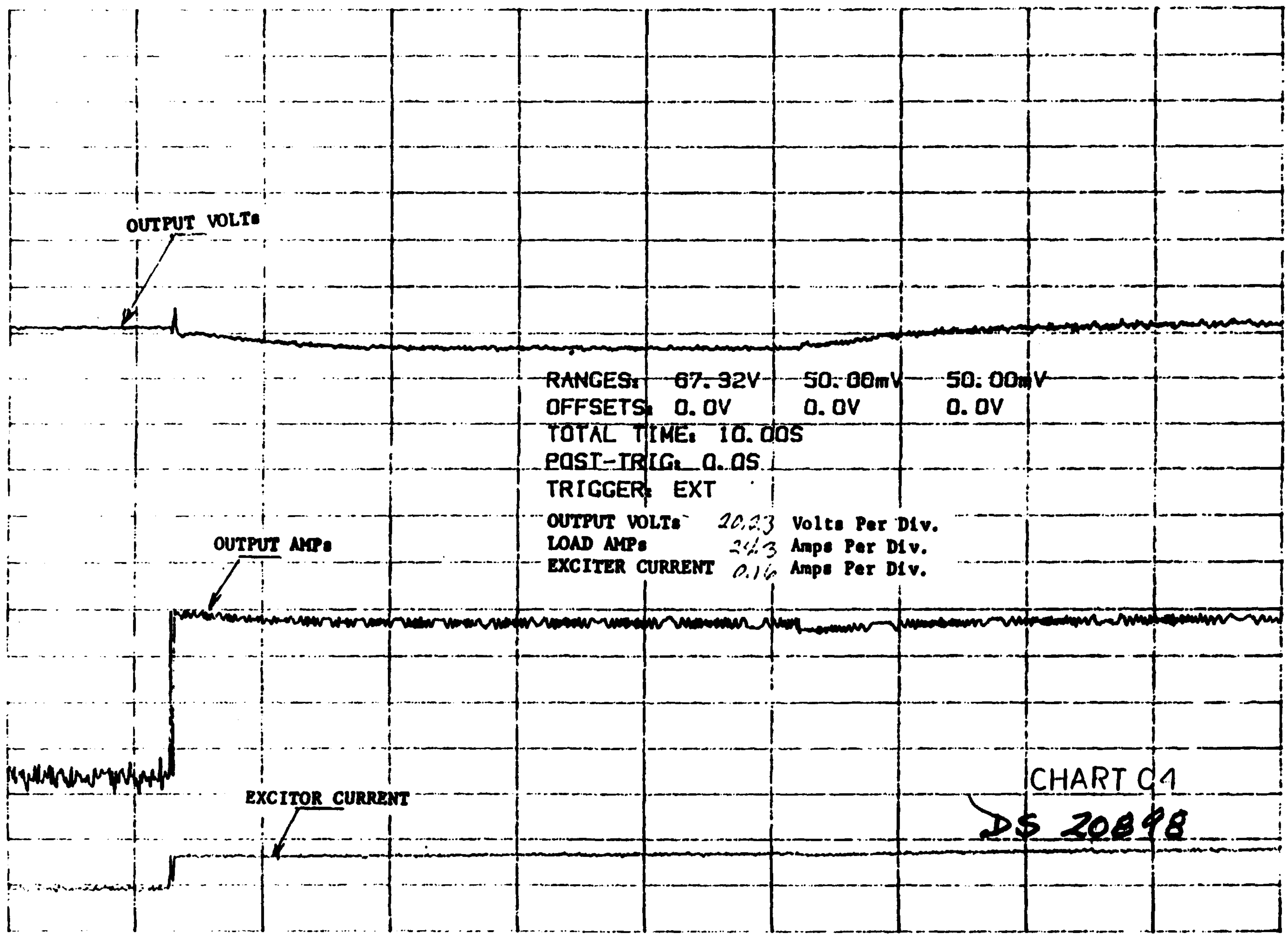

OUTPUT VOLTs
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 2.13 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART C2
DS 20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.92V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART C3
DS20898


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART 3D
DS 20898



OUTPUT VOLTs
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
OUTPUT AMPs
EXCITOR CURRENT
CHART 3E
DS 200 98


OUTPUT VOLTs
OUTPUT AMPs
EXCITOR CURRENT
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTs 20.23 Volts Per Div.
LOAD AMPs 243 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.
CHART C1
DS 20898

5.11 Protection Performance

Purpose: the purpose of the series of tests performed was to confirm that system protection circuitry functioned properly.

Procedure: The tests required to demonstrate protection performance were done according to the acceptance test procedure for the 51527-000 generator control unit. A copy of the test procedure, LAPEC specification 17-510121, is appended to this section.

Results: Test results are shown on: LAPEC data sheets 19932 through 19940 for unit serial number 103; LAPEC data sheets 22042 through 22050 for unit serial number 104.

Discussion of Results: The test data indicates, that the GCU's performed in accordance with the requirements specified by the preliminary test specification 17-510121.

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

DWG NO. 17-510121

E	
P	

RELEASED BY: *A.b. Olench* DATE: *8/16/85*

REV																																						
SHEET	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72

REV STATUS	REV																																		
OF SHEETS	SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCE ON
DECIMALS ANGLES
XX ± .01 XXX ± .005 ± 0 30'

DO NOT SCALE THIS DRAWING

MATERIAL

CONTRACT NO.

DRAWN BY DATE

CHECKED BY

MATL APVD

CMPNT ENGR

MECH ELECT
DSGN APVD

PROJECT ENGR *[illegible] 8/7/85*

Lucas Aerospace
Lucas Aerospace Power Equipment Corporation

Acceptance Test Procedure for 51527-000
Generator Control Unit

SIZE	FSCM NO.	DWG. NO.
A	31435	17-510121

SCALE SHEET 1 OF 10

1.0 SCOPE

1.1 This specification establishes the acceptance test requirements for the Generator Control Unit (GCU) for controlling 270 volt direct current generator. Such a system is defined as a single or isolated system. Two or more of these systems connected to the same load bus constitute a parallel system. This system is designed to meet Specification No. NADC-60-TS-7803 of the Department of the Navy.

1.2 Type

The Generator Control Unit and the associated current sensor assemblies shall be self cooled and designed to maintain a constant generator output voltage and provide equal load distribution in a parallel generator system.

2. APPLICABLE DOCUMENTS

The following documents from a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

NADC-60-TS-7803	Generator System, 270 VDC Oil Cooled, Aircraft, General Specification for

Military

MIL-T-704	Treatment and Painting of Material
MIL-D-1000	Drawings, Engineering and Associated Lists

STANDARDS

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property

MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-810	Environmental Test Methods
MS33543	Criteria - Temperature and Altitude Range, Self Cooled Electric Equipment

LSI/PED

Publications and Drawings

515270000	Outline, Generator Control Unit
51527-100	Schematic and Inter-connection Diagram
51527-250	System Interconnection Diagram
51527-310	Printed Wiring Board Assy, Voltage Regulator Circuit
51527-320	Printed Wiring Board Assy, Logic Circuit
51527-330	Printed Wiring Board Assy, Control Circuit
51527-340	Printed Wiring Board Assy, Control Circuit
51527-300	Wiring Diagram

3.0 <u>REQUIREMENTS</u>

3.1 General:

The test and inspection defined herein demonstrate compliance of the 51527-000, Generator Control Unit, to the applicable requirements of Navy Specification No. NADC-60-TS-7803.

3.2 Test Equipment:

The equipment listed in Tables 1 thru 3 are required to accomplish the test defined herein. Substitution, with equivalent or better items, is permitted.

3.2.1 Instrumentation:

Table 1, provides a list of the instruments and the accuracies needed for the measurements specified. Special go/no go indicators or circuits may be substituted for direct readings provided that evaluation accuracy is maintained.

3.2.1.1 Calibration:

All instruments shall be calibrated in accordance with the calibration requirements of MIL-C-45662.

3.2.2 Power Supplies:

Power supplies used in conjunction with the test of the unit shall have characteristic equal to or exceeding the list of Table 2.

3.2.3 External Loads:

Table 3 lists the external loads, that are connected during the testing of the GCU.

3.3 Test Conditions:

All acceptance tests shall be performed under the following conditions.

3.3.1 Environmental Conditions:

Temperature (ambient):	25° +/- 10°C (50°F to 104°F)
Atmospheric Pressure:	28 to 31 in. Hg.
Vibration:	None
Humidity:	Room ambient, up to 90% RH
Generator Speed:	16,000 +/- 600 RPM

3.3.2 Test Configuration:

The GCU shall be tested with its base down and horizontal and all connections shall be made thru the connectors or test points.

Figure 2 illustrates the GCU without the top and bottom cover and the location of the adjustment potentiometers on the printed circuit boards.

3.4 Acceptance Test:

3.4.1 Examination of Product:

Each unit shall be examined for conformance with the drawing 51527000 with respect to weight, dimensions, materials, finishes, markings, proper parts, soldering and workmanship.

3.4.2 Dielectric Strength:

Remove the three printed wiring board assemblies and perform dielectric tests between chassis ground J1-7 & -53 and all other pins of J1 a J2 together. as follows:

a) With pins -13, 15, 16, 17, 18, 38, 40, 41, 43, 44, 46, 49, 50, 52, 55 tied together apply 1500 VAC for 1 minute.

b) With the remaining pins of J1 and J2 tied together apply 500 VDC for 1 minute.

The leakage current shall not exceed 100 microamperes and there shall be no evidence of flashover (surface discharge) or breakdown (puncture).

3.4.3 Functional Tests:

The open loop functional test shall be performed first, followed by the closed-loop verification tests. Figure 1 shows the recommended test configuration for the GCU and also for the entire electrical system.

3.4.3.1 Open Loop Test:

Note: The test configuration of Figure 1 is recommended for open loop testing, using the PMG of the generator as power supply (PS No. 2). Also as an alternate equivalent to Sostel, the outputs at J2 connector can be tested with a 10 mA constant current supply.

3.4.3.1.1 **Power Supplies:**

With 350 VAC (L-L) 1200 Hz. power, applied between pins -52, -50 and -49 of connector J1 of the GCU measure the following voltages:

+15.0 +/-1.0 VDC, between TP9-TP8 of PWB No. 1
+26.5 +/-1.0 VDC, between TP1-TP8 of PWB No. 1
+26.5 +/-1.0 VDC, between pins 28-17 of J1
27.0 +/-10.0 VDC, between pins; 47-17 of PWB No. 1

3.4.3.1.2 **Ripple Voltage Protection:**

a. With power supplied as in para. 3.4.3.1.1, connect an adjustable voltage and frequency single phase AC power source (PS No. 3) to switch 4 position 1. Monitor TP7 of PWB No. 3 and pin 1 of J2 (Sostel) connector. It shall read 720 +/-150Ω (or an equivalent 7.2 +/-1.5 VDC).

b. Set the frequency to 4 KHz and increase the output voltage of the single phase power supply to read 12V (p-p). Adjust R312 until TP7 switches to "Lo" (0.0 + .5 VDC), and 6.0 +/-1 seconds later J2-1 reads 420 +/-50Ω (or 4.2 +/-1.0 VDC). Return all switches to the configuration of Figure 1.

3.4.3.1.3 **Failed (Open) Rectifier Detection:**

a. With power applied as in para. 3.4.3.1.1, connect the output of PS No. 3 to J1-13 (temporarily, disconnect the wiring to the generator, J1-2). Monitor TP6 of PWB No. 3 and pin 3 of J2 (Sostel).

TP6 shall be in the "Hi" state and J2-3 shall read 720 +/-150 (or 7.2 +/-1.5 VDC).

b. Set the frequency of PS No. 3 to 2 KHz and slowly increase the output voltage. When the peak-to-peak value exceeds 6.0

volts TP6 shall switch to "Lo" state (adjust R331 if required). 6.0 +/-1 seconds later the J2-3 shall read 420 +/- 50Ω (or 4.2 +/- 1.0 VDC).

3.4.3.1.4 Failed (Shorted) Rectifier Detection:

a. With condition of para. 3.4.3.1.3 maintained read J2-2. It shall read 720 +/-150 (or 7.2 +/-1.5 VDC).

b. With a jumper lead short TP2 of PWB No. 1 to TP8, and observe the reading changing to 420 +/-50Ω (or 4.2 +/-1.0 VDC) at J2-2. Return all switches to the configuration of Figure 1. Open all switches.

3.4.3.2 Closed-Loop Test (Single System)

3.4.3.2.1 Start-up and Shutdown operations

a. Set the switches of Figure 1 in the following positions.

S1, S2 - Position 1
S3, S4 - Position 2
GCSw - "ON"

Connect the system (Generator, GCU, CS #1 & #2, LC and BTC) as shown on Figure 1. The constant current monitoring system (Sostel) shall give the following indications between pin J2-9 (GND) and the following pins of J2 of the GCU:

J2-1	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-2	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-3	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-4	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-5	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-6	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-7	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-8	-	720Ω +/-150	or	7.2 +/-1.5 VDC
J2-10	-	1100Ω +/-200	or	11.0 +/-2.0 VDC
J2-11	-	1100Ω +/-200	or	11.0 +/-2.0 VDC

b. With an oscilloscope monitor TP4 of PWB

No. 3, while starting the generator drive. Initially the voltage at the monitor point will slowly increase in proportion to the speed of the generator, then reaches a constant value of 14 +/-1.0 VDC ("Hi" state). L1 and L2 indicator lights shall be ON. When the generator speed reaches 8000 +/-600 RPM, the Generator output voltage shall read 270 +/-5 VDC (adjust R100 ~~for voltage~~ SPEED and R334 for . .. if required). Indicator lights L1 & L2 shall be OFF, and TP4 of PWB No. 3 shall switch to the "Lo" state. The generator load current indicator shall show the 5 amps pre-load.

c. Set the Generator speed to 9,000 +/-50 RPM and apply .5, 1.0 and 1.25 PU (167 amp) load current. The voltmeter at the POR shall have +/-5 volts regulation limits (from no load setting of step b) for all loads, except for 1.25PU, where it shall be 270 +/-10 volts.

d. Increase the generator speed to 18,000 RPM and repeat step c).

e. Reduce speed to 16,000 RPM and repeat step C.

f. Using the constant current source and the monitoring system read the status of J2 signals. They shall read as follows:

J2-1	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-2	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-3	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-4	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-5	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-6	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-7	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-8	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-10	-	720 +/-150Ω	or	7.2 +/-1.5 VDC
J2-11	-	720 +/-150Ω	or	7.2 +/-1.5 VDC

g. Move the GCSw to OFF (middle) position. L1 L2 shall go ON, POR voltage drops to zero and J2-11 shall read 420 +/-50Ω (or 4.2 +/- 1.0 VDC).

h. Move the GCSw to test position. The POR voltage shall read 270 +/-10 VDC, L1 and L2 remain unchanged.

i. Move the GCSw back to OFF and to ON position. L1 and L2 shall be OFF and J2 status pins read as in step f.

j. Monitor TP1 and TP4 of PWB No. 3 while reducing the speed of the generator. When the generator speed drops below 8000 +/-500 RPM, TP4 switches into the "Hi" state. (Adjust R334 if required) 2-3 seconds later TP1 switches "Lo", both indicator lights (L1, L2) shall go ON and the POR voltage drops to zero. J2-11 shall read 420 +/-50Ω.

3.4.3.2.2 Overvoltage Protection Test:

a. With the system operating at 16,000 +/-100 RPM, adjust R100 of PWB No. 1 to increase the requlated output voltage of the generator. Monitor TP3 of PWB No. 1 and J2-3 of the Sostel output connector. TP3 shall be in the "Lo" state and J2-3 shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC). L1 and L2 are ON.

b. When the output voltage of 290 VDC is reached TP3 switches momentarily to "Hi" (Adjust R101 if required). The generator is de-energized, L1 & L2 shall go ON and J2-3 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

c. Move the GCSw to OFF and back to ON position. There shall be no change in the status (J2) and indicator lights conditions.

d. Readjust R100 to step a) condition and move the GCSw to OFF and back to ON position. L1 & L2 shall go OFF and J2-3 shall read again as in step a).

3.4.3.2.3 Undervoltage Protection Test:

a. With the system operating at 16,000 +/- 100 RPM, adjust R100 of PWB No. 1 to decrease the regulated output of the generator. Monitor J2-7 and J2-11. They shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC). L1 & L2 shall be OFF.

b. After the POR voltage of 245 +/-5 VDC is reached the generator is de-energized, (Adjust R306 if required) L1 & L2 go ON and J2-7 and J2-11 read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

c. Move the GCSW to OFF and back to ON position. The generator shall build-up to the set level but 5-7 seconds later shall de-energized again. L1 & L2 and J2-7 status remain unchanged.

d. Readjust R100 to step a) condition and repeat the reset test of step c). The generator shall build-up to 270 +/-5 VDC. L1 & L2 shall be OFF and J2-7 and J2-11 shall read the same as in step a).

3.4.3.2.4 Feeder Fault Protection Test:

a. With the system operating at 16,000 +/-100 RPM, monitor TP5 of PWB No. 3 and pins -5 and -11 of the Sostel connector (J2). TP5 shall be in the "Hi" state and J2-5 and 11 shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC)./ L1 & L2 shall be OFF.

b. Apply a fault current of 63 +/-5 amps between the protective zone of CS #1 and CS #2. (Generator terminal to line contactor) while monitoring TP5 of PWB No. 3 and the respective Sostel outputs (J2-5 and J2-11).

Less than 50 milliseconds after a fault application TP5 switches to "Lo" state, L1 & L2 shall go ON and J2-5 and J2-11 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

c. Attempt a GCSw reset with the fault still applied between the protective zone. There shall be no change in the indicator light or the Sostel output monitor status.

d. Remove the fault and repeat reset action. The generator shall energize, L1 & L2 shall be OFF and J2-5 and J2-11 shall read the values recorded in step a).

3.4.3.2.5 Overcurrent Protection Test

a. With the system operating at 16,000 +/-100 RPM. Apply 1.0 PU (167 amps) to the generator. Monitor the POR voltage and J2-6 of Sostel. The voltage shall be 270 +/-5 VDC and J2-6 shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC). L1 & L2 shall be OFF.

b. Increase the load current to greater than 250 amps. Attempt to further increase the load current will result in decrease of the POR voltage while the load current remains essentially the same. Seven seconds after the application of the overload the generator will be de-energized. L1 & L2 shall go ON and J2-6 and J2-11 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

c. Remove the overload and return the system to the normal operating conditions of step a).

3.4.3.2.6 Generator Warning and Disconnect Test:

NOTE: Generator Disconnect testing is done during qualification testing, therefore, only simulated test shall be performed here, using the power resistor R1 as the disconnect coil.

a. With the system operating at 16,000 +/-100 RPM, read the status of pins -10 and -11 of Sostel connector J2. They shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC) and L1 & L2 shall be OFF. With a scope monitor R1 voltage. It shall indicate a "Lo" state.

b. Momentarily ground pin 12 of J1 connector. 200 +/-50 milliseconds after application, the scope shall switch to "Hi" (270 volts) state, the generator shall be de-energized (L1 & L2 ON) and J2-10 shall read 1100 +/-200 (or 11.0 +/-2.0 VDC) and J2-11 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

c. Remove the short (ground) from J1-12 of the GCU and reset the system by moving momentarily the GCSw to OFF and back to ON position. All indication and readings shall be the same as in step a).

d. Open wire J1-10 at the GCU and read the generator status indicator J2-10. It shall read 1100 +/-200Ω (or 11.0 +/-2.0 VDC). All other indications remain normal.

At this point, the GCU has completed the requirement for control and protection of a single high voltage electrical system.

4. <u>QUALITY ASSURANCE PROVISIONS</u>

4.1 The Quality Control Department shall establish the necessary procedures and controls to assure conformance with the requirements of this specification with regard to test methods, test equipment, instrumentation and failure reporting.

4.2 Test Records:

Certified test reports shall be prepared for each unit successfully completing the Acceptance Test. One copy of the test report shall be retained on file by the Quality Control Department and a copy shall accompany each unit that is delivered.

4.2.1 Data Sheet:

The test report shall be prepared on a data sheet that shall contain, as a minimum, the following information.

a. Unit model number and nomenclature
b. Test specification number and revision level
c. Unit serial number
d. Adequate test records shall be prepared for each unit subjected to the acceptance tests herein, recording pertinent data as required in the detail tests
e. Weight

4.3 Rejection, Retest, and Failure Reporting

4.3.1 Rejection and Retests:

Units that are rejected during Acceptance Testing may be reworked or have parts replaced to correct the detect and then may be resubmitted for Acceptance Test.

4.3.2 Failure Reporting:

In cases of requirement, the Quality Control Department shall report each failure occurring during Acceptance Testing in accordance with specification 99-520000. A copy of this report shall be submitted to LSI/PED Reliability.

4.3.3 Disposition of Failed Parts:

Failed parts shall be appropriately

identified and retained until a failure analysis has been performed by Quality Control and/or Reliability Engineering.

5. Definitions, Tables, and Figures.

5.1 Definitions and Abbreviations

5.1.1 Definitions

5.1.1.1 Point of Regulation:

The point at which the regulator senses and establishes system voltage for Acceptance Test purposes.

5.1.1.2 Rating:

System rating shall be 45KW, based on 270V volts at the generator terminal.

Abbreviations

GCU - Generator Control Unit
VAC - Volts Alternating Current
VDC - Volts Direct Current
Hz - Hertz
I - Point of Regulation
GCSw - Generator Control Switch
CSA - Current Sensor Assembly
PWB - Printed Wiring Board
PS - Power Supply

5.2 Tables

5.2.1 Table 1 Instrument List
5.2.2 Table 2 Power Supply List
5.2.3 Table 3 External Load List

5.3 Figures

5.3.1 Figure 1 HVDC Electrical System
5.3.2 Figure 2 Generator Control Unit

Table I

Instrument List

Function	Range Required	Accuracy % of Range	Notes
Dielectric Voltage	15000 VAC 0-1000 ua	3% 3%	60 Hz
Continuity	0-.2 ohm	2%	4.5 VDC max
Resistance	5-600 ohm	0.1% of reading	
AC Voltage	0-1999 VAC +/-.15% of reading	+/-1 digit scale	
DC Voltage	0-300 VDC	.5% full scale	
Oscilloscope	.1-10u sec/div 50/10 mv/div	3% 3%	For ripple, waveform and time measurement
Events of Unit Time Counter	300-15000 cycles	+/-1.1 counts	Frequency (speed) and time measurements
DC Current	0-500 amps	1% of range	

Table 3

Special Load List

Load Designations	Description	Value	Wattage	Notes
R1	Fixed Resistor	2.7K	50W	Figure 1
R2	Fixed Resistor	550 Ω	150W	Figure 1
L1, L2	Indicator Lights	28.0V	1/4W	Figure 1

Table 2

Power Supply List

Source Designation	Source Type	Required value or range	Accuracy	Load	Notes
PS No. 1	Voltage DC	0-400 VDC	+/-.1 VDC	.5 amps	Figure 1
PS No. 2	3 AC	0-300 VAC (L-L)	+/-10 VAC	2.0 amps	Figure 1
PS No. 3	Voltage AC	0-30 VAC	+/-1.0 VDC	1.0 amps	Figure 1
PS No. 4	Voltage DC	0-50 VDC	+/-.1 VDC	.5 VDC	Figure 1
PS No. 5	Current, Constant	0-10 mA	+/-1.0 mA	Variable	Figure 1

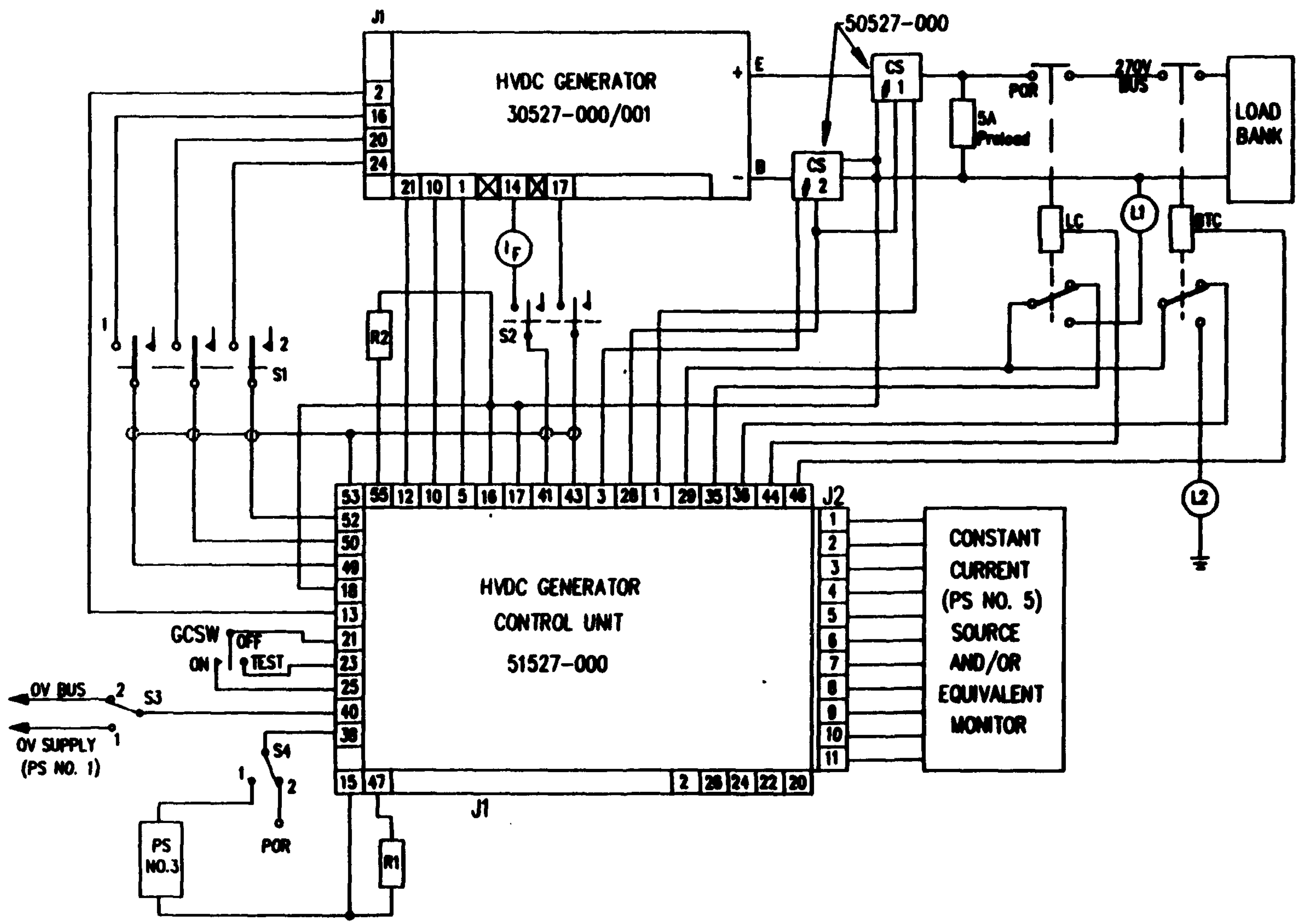
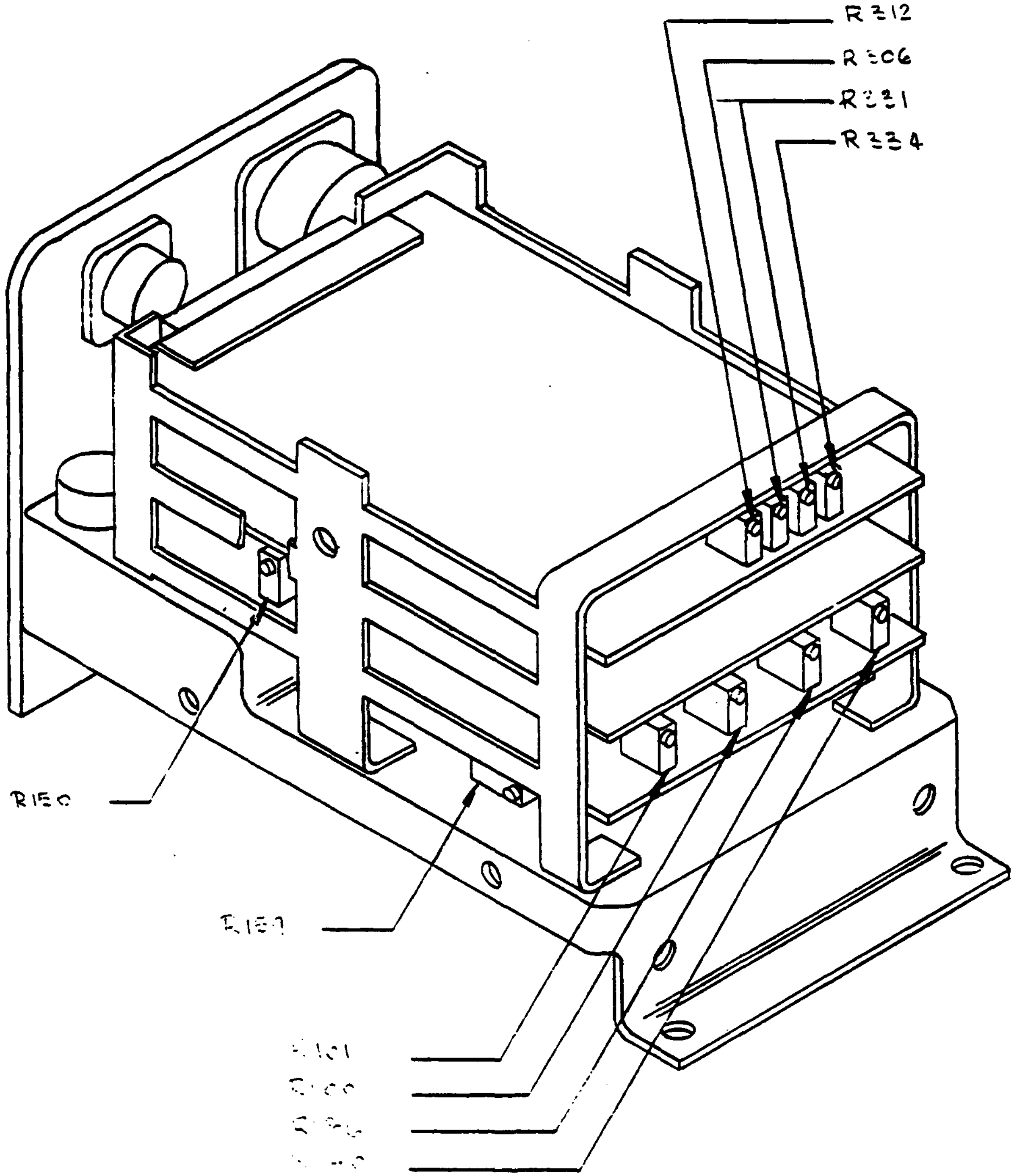


Figure 1 HVDC Electrical System



Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

SIZE	FSCM NO	DWG. NO.
A	31435	17-510121
SCALE	REV	SHEET 19 OF 19

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. Harmat

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. QP 387 TESTED BY R. J. Saniuk

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121 PAGE 1 OF 9

PARA. NO.	TIME	AMB. TEMP.	
3.4.3.1			OPEN LOOP
4.3.1.1			POWER SUPPLIES
			350VAC (L-L) 1200 Hz IN
	A		TP8 = 15.03V
	B		TP1 = 27.32
	C		PIN 38 = 27.39
	D		PIN 47 = 3.15V
4.3.1.2			RIPPLE VOLTAGE PROTECTION
	A		TP7-PWB3 = "Hi" 14.92V PIN 1 OF J2 = 7.7V
	B		TP7-PWB3 = "Low" 00.90V PIN 1 OF J2 = 5.1V
			TIME IN SEC = 5 SEC
4.3.1.3			FAILED (OPEN) RECTIFIER DETECTION
	A		TP6-PWB3 = "Hi" - 14.95V
			J2-8 = 7.7V
	B		TP6-PWB3 = "Low" - 0.9V
			J2-8 = 5.1

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NO: 19932

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 COG. ENGR. HARMAT

ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.			
4.3.1.4			FAILED (SHORTED) RECTIFIER DETECTION		
	A.		J2-2	=	7.7 V
			J2-2	=	5.1 V
4.3.2.0			CLOSED LOOP (SINGLE SYSTEM)		
4.3.2.1			START-UP AND SHUTDOWN OPERATIONS		
	A		J2-1	=	7.7 V
			J2-2	=	7.7 V
			J2-3	=	7.7 V
			J2-4	=	7.7 V
			J2-5	=	7.7 V
			J2-6	=	7.7 V
			J2-7	=	7.7 V
			J2-8	=	7.7 V
			J2-10	=	11.7 V
			J2-11	=	11.7 V

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. Harmat

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. QP 387 TESTED BY R. J. Saniuk

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
3.4.3.2			START-UP AND SHUT DOWN OPERATIONS
	B		TP4-PWB3 "Hi" 14.2 V (8000 (RPM)
	1		TP4-PWB3 "Low" 0.9 V (8400) (RPM)
			INDICATOR LIGHTS - "OFF"
			P.O.R. = 270.5V WITH 5 Amp PRE-LOAD
	C		9000 RPM 272.3 V 5 Amp PRE-LOAD
			9000 RPM 268.1 V 84 Amp LOAD
			9000 RPM 267.3 V 167 Amp LOAD
			9000 RPM 264.3 V 208 Amp LOAD
	D		7650 RPM 266.3 V 84 Amp LOAD
			7650 RPM 267.4 V 167 Amp LOAD
			7250 RPM 267.0 V 210 Amp LOAD
	E		16000 RPM 265.9 V 84 Amp LOAD
			16000 RPM 267.1 V 167 Amp LOAD
			16000 RPM 267.0 V 210 Amp LOAD

G 5.2

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NO. 19934

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. Harma

E.W.O. 54805 MODEL NO. 61527-000 SERIAL NO. 103 ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. AP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121 PAGE 4 OF 9

PARA. NO.	TIME	AMB. TEMP.		
3.4.3.21			START-UP AND SHUTDOWN OPERATIONS	
	F.		16000 rpm ½ Load (84 amp)	
		J2-1	=	7.7V
		J2-2	=	7.7V
		J2-3	=	7.7V
		J2-4	=	7.7V
		J2-5	=	7.7V
		J2-6	=	7.7V
		J2-7	=	7.7V
		J2-8	=	7.7V
		J2-10	=	7.9V
		J2-11	=	7.9V
	G.		LITES ARE "ON"	
			P.O.R.	0.0 V
			J2-11	5.0 V
	H		LITES - ARE "ON"	
			P.O.R.	V
	J		LITES ARE "OFF"	
			P.O.R.	26.8 V
			J2-	STATUS SAME AS STEP F.

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NO. 19935

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. QP 387 TESTED BY R.J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP	
4.3.2.1			START-UP AND SHUT-DOWN OPERATIONS
	J		TP4-PWB3 "Hi" STATE } NORMAL OPERATION
			TP4-PWB3 LOW STATE }
			GENERATOR SPEED BELOW 8000 RPM
			TP4-PWB3 SWITCHES TO "Hi" STATE
			2.2 SEC
			TP1-PWB-3 SWITCHES TO "LO" STATE
			LITES ARE "ON" P.O.R VOLTAGE "0"
4.3.2.2			OVERVOLTAGE PROTECTION TEST
	A.		16000 RPM, 84 AMP 266 V
			TP3 PWB1 "LOW" STATE
			J2-8 27 V
			LITES "OFF"
	B		OUTPUT RAISED TO 290 VDC
			TP3 PWB1 SWITCHES "Hi" MOMENTARILY
			GENERATOR DE-ENERGIZED
			LITES "ON"
			J2-3 = 5.1 V

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NO: 19936

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 COG. ENGR. HARMAT

ROTOR NO. STATOR NO.

DATE OF TEST 5/27/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121 PAGE 6 OF 9

PARA. NO.	TIME	AMB. TEMP.	
4.3.22			OVERVOLTAGE PROTECTION TEST
	C		NO CHANGE (SAME AS B)
	D		NORMAL OPERATION
			LITES "OFF"
			J2-3 7.7 V
4.3.23			UNDERVOLTAGE PROTECTION TEST
	A.		1600 RPM 84 AMP 266 V
			J2-7 = 7.7 V
			J2-11 = 8.0 V
	B		POR VOLTAGE DECREASED TO 243 V
			J2-7 = 5.1 V
			J2-11 = 5.1 V
			LITES "ON" (GENERATOR DE-ENERGIZED)
	C		GCSW SWITCH FROM "ON" TO "OFF" TO "ON"
			GENERATOR IS ENERGIZED (266 V) FOR 5 SEC. THAN IS TRIPPED OFF
			LITES ARE "ON"
			J2-7 AND 11 SAME AS "B"

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POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 163 COG. ENGR. Harmat

ROTOR NO. STATOR NO.

DATE OF TEST 5/27/88 TEST LETTER: NO. QP387 TESTED BY R. J. Saniuk

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.23			UNDERVOLTAGE PROTECTION TEST
	D.		POR ADJUSTED TO 262.9V
			NORMAL OPERATION
			LITES "OFF"
			J2-7 AND 11 SAME AS STEP "A"
4.3.24			FEEDER FAULT PROTECTION TEST
	A.		16000 RPM 84 Amps 262.9 V
			TP5-PWB3 = "Hi" STATE
			J2-5 = V 7.7V
			J2-11 = V 8.2V
			LITES ARE "OFF"
	B		A 63.5 AMP FAULT IS APPLIED TO SYSTEM
			SYSTEM
			TP6-PWB3 "Lo" STATE
			J2-5 61 V
			J2.11 61 V
			LITES ARE "ON"

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EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 ROTOR NO. STATOR NO.

DATE OF TEST 5/27/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.24			UNDER VOLTAGE PROTECTION TEST
	C		SYSTEM WILL NOT RESET INTO FAULT
			LITES "ON"
			J2-5 AND 11 SAME AS STEP B (NO CHANGE)
	D		FAULT REMOVED AND SYSTEM RESET
			OPERATION
			LITES "OFF"
			J2-5 AND 11 SAME AS STEP A
4.3.2.5			OVERCURRENT PROTECTION TEST
	A		1600RPM 167A 269.0V
			J2-6 = 7.7V J2-11 = 8.2 V
			POR 269.0 VDC
			LITES ARE "OFF"
	B		LOAD INCREASE TO GREATER THAN 250A AND APPLIED 260 A FOR 7 SECONDS, GENERATOR DE-ENERGIZED
			LITES "ON"
			J2-6 AND 11 = 5.1 V
	C		OVERLOAD REMOVED, RESET, NORMAL OPERATION

264A 183.V

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NO. 19939

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. Harmai

E.W.O. 54805 MODEL NO. 67527-000 SERIAL NO. 103 ROTOR NO. STATOR NO.

DATE OF TEST 5/27/88 TEST LETTER NO. QP 287 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.26			GENERATOR WARNING AND DISCONNECT TEST
			SIMULATED TEST POWER RESISTOR USED IN PLACE OF DISC COIL
	A		16000 RPM, 269 VDC
			J2-10 = 8.2 V
			J2-11 = 8.2 V
			LTES ARE "OFF"
			RES VOLTAGE "LOW" STATE
	B		PIN 12 J1 SHORTED TO GND (PIN 12 OF U210)
			RES VOLTAGE "HI" STATE
			J2-10 = 11.5 V
			J2-11 5.1 V
			LTES ARE "ON"
	C		REMOVE SHORTED PIN 12 J1
			RESET SYSTEM OPERATION NORMAL.
	D		OPEN J1 PIN 10
			J2-10 11.5 V
			OTHER INDICATIONS NORMAL.

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NO: 19940

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY. TEST RECORD

COG. ENGR. Harmat

W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 ROTOR NO. STATOR NO.

DATE OF TEST 6/1/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

RUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121 PAGE 1 OF 9

PARA. NO.	TIME	AMB. TEMP.	
4.3.1			OPEN LOOP
4.3.1.1			POWER SUPPLIES
			350 VAC (L-L) 1200 Hz 1Ø
	A		TP2 = 14.96
	B		TP1 = 26.91
	C		*PIN 28 = 26.92
	D		*PIN 47 = 296.0
4.3.1.2			RIPPLE VOLTAGE PROTECTION
	A		TP7-PWB3 = Hi = 14.77V PIN 1 OF J2 = 7.7V
	B		TP7-PWB3 = Low = 00.01V PIN 1 OF J2 = 4.9V
			TIME IN SEC. 5 SEC
			[redacted]
4.3.1.3			FAILED (OPEN) RECTIFIER DETECTION
	A.		TP6-PWB3 = Hi = 14.78V
			J2-8 = 7.2V
	B.		TP6-PWB3 = Low = 0.09V
			J2-8 = 5.05V.

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG. NO: 22012

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT

W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 ROTOR NO. STATOR NO.

DATE OF TEST 6/11/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.			
4.3.1.4			FAILED (SHORTED) RECTIFIER DETECTION		
	A		J2-2	=	7.7V
	B		J2-2	=	5.05V
4.3.2.0			CLOSED-LOOP (SINGLE SYSTEM)		
4.3.2.1			START-UP AND SHUTDOWN OPERATIONS		
	A.		J2-1	=	7.7V
			J2-2	=	7.7V
			J2-3	=	7.7V
			J2-4	=	7.7V
			J2-5	=	7.7V
			J2-6	=	7.7V
			J2-7	=	7.7V
			J2-8	=	7.7V
			J2-10	=	11.6V
			J2-11	=	11.6V

FORM 1349 R/S (12/63) PRECEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG. ______

NO: 22043

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY. TEST RECORD

W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 COG. ENGR. HARMAT

ROTOR NO. STATOR NO.

DATE OF TEST 6/11/88 TEST LETTER: NO. QP387 TESTED BY R.J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
13.2.1			START-UP AND SHUTDOWN OPERATIONS
	B.		TP4 - PWB-3 (HI) 14.2V (5000 RPM)
			TP4 - PWB-3 (LOW) 0.0V (8400 RPM)
			INDICATOR LIGHTS (L1) OUT. (OFF)
			POR = 270 +/- 5V WITH 5 Amp PRE-LOAD.
	C.		9000 RPM 278.4V 5A PRE-LOAD
			9000 RPM 268.2 V 84A LOAD
			9000 RPM 267.2 V 167A LOAD
			9000 RPM 263.6 V 210A LOAD
	D.		17500 RPM 265.7V 84A LOAD
			17500 RPM 267.3 V 167A LOAD
			17500 RPM 267.1 V 208A LOAD
	E.		16000 RPM 266.0 84A LOAD
			16000 RPM 267.6 167A LOAD
			16000 RPM 267.3 208A LOAD

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 COG. ENGR. Harmat

ROTOR NO. STATOR NO.

DATE OF TEST 6/11/88 TEST LETTER: NO. QP 387 TESTED BY R. J. Saniuk

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: Acceptance Test Procedure 17-510121

PARA. NO.	TIME	AMB. TEMP.			
4.3.2		START-UP AND SHUTDOWN OPERATIONS			
	F.	16000 RPM 1/2 Load (8KA)			
		J2-1	=	8.0 V	
		J2-2	=	8.0 V	
		J2-3	=	8.0 V	
		J2-4	=	8.0 V	
		J2-5	=	8.0V	
		J2-6	=	8.0V	
		J2-7	=	8.0V	
		J2-8	=	8.0 V	
		J2-10	=	8.1 V	
		J2-11	=	8.1 V	
	G.	Lites		"ON"	
		PoR		"0" V	
		J2-11		5.05V	
	H.	Lites		"ON"	
		Po.R.		267.5V.	
	i.	Lites		"OFF"	
		PoR.		267.6 V	
		J2 status same as step F.			

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG. ______

NO: 22045

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 COG. ENGR. HARMAJ

ROTOR NO. STATOR NO.

DATE OF TEST 6/12/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.2.1			START-UP AND SHUT-DOWN OPERATIONS
	j		TP1-PWB-3 Hi STATE } normal operation.
			TP4-PWB-3 Low STATE }
			GENERATOR SPEED BELOW 8000 +/-500
			TP4 PWB-3 SWITCHES TO Hi STATE.
			2 SEC. +/-0.5
			TP1-PWB-3 SWITCHES TO LOW STATE
			LTES ARE "ON" P.O.R. VOLTAGE 0.0V
4.3.2.2			OVERVOLTAGE PROTECTION TEST
	A.		16000 RPM, 84A, 265.5 V
			TP3 PWB 1 "LOW" STATE
			J2-3 = 7.7V
			LTES "OFF"
	B.		OUTPUT RAISED TO 290VDC
			TP-3 PWB 1 SWITCHES "Hi" MOMENTARILY
			GENERATOR DE-ENERGIZED
			LITES "ON"
			J2-3 = 5.06V

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 ROTOR NO. STATOR NO.

DATE OF TEST 6/12/88 TEST LETTER: NO. QP 387 TESTED BY R.J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.2.2		OVER VOLTAGE PROTECTION TEST	
	C.		NO CHANGE (SAME AS B).
	D		NORMAL OPERATION.
			LTES "OFF"
			J2-3 7.7V
4.3.2.3		UNDER VOLTAGE PROTECTION TEST.	
	A.		16000 RPM 84A 267V
			J2-7 = 7.7V
			J2-11 = 8.1V
	B.		POR VOLTAGE DECREASED TO 242V
			J2-7 = 5.1
			J2-11 = 5.1
			LTES "ON" (GENERATOR DE-ENERGIZED)
	C.		GCSW SWITCH FROM "ON" TO "OFF" TO "ON"
			GENERATOR IS ENERGIZED (270V) FOR 5.5 SEC. THAN IS TRIPPED OFF
			LTES ARE ON.
			J2-7 AND 11 SAME AS "B"

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. ______ FOLLOWING PAGE NO. ______ A.F. SIG

NO. 22047

POWER EQUIP. GRP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. *Harmat*

W.O. *54805* MODEL NO. *51527-0011* SERIAL NO. *104* ROTOR NO. STATOR NO.

DATE OF TEST *6/12/88* TEST LETTER: NO. *QP387* TESTED BY *R. J. SANIUK*

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: *ACCEPTANCE TEST PROCEDURE 17-510121*

PARA. NO.	TIME	AMB. TEMP.	
4.3.23.			UNDERVOLTAGE PROTECTION TEST
	D.		POR ADJUSTED TO 269.4V
			NORMAL OPERATION.
			LITES "OFF"
			J2-7 AND 11 SAME AS STEP A
4.3.24			FEEDER FAULT PROTECTION TEST
	A.		16000 RPM, 8YA 248V.
			TPS-PWB 3 = "Hi" STATE
			J2-5 = 7.7V
			J2 11 = 8.1V
			LITES ARE "OFF"
	B.		A 13.5A FAULT IS APPLYED TO SYSTEM
			SYSTEM TRIPPED.
			TPS-PWB 3 - "Low" STATE
			J2-5 = 5.1V
			J2-11 = 5.1V
			LITES ARE "ON"

M.V.S.

FORM 1349 R/5 (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG. NO: 22048

POWER EQUIP CORP.

EXPERIMENTAL LABORATORY TEST RECORD

W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 COG. ENGR. HARMAT

ROTOR NO. STATOR NO.

DATE OF TEST 6/12/88 TEST LETTER: NO. OP387 TESTED BY R. J. SANIUK

RUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121 PAGE 8 OF 9

PARA. NO.	TIME	AMB. TEMP.	
1.3.2.4			UNDERVOLTAGE PROTECTION TEST
	C.		SYSTEM WILL NOT RESET INTO FAULT
			LITES "ON"
			J2-5 AND 11 SAME AS STEP B.
	D.		FAULT REMOVED AND SYSTEM RESET.
			NORMAL OPERATION.
			LITES "OFF"
			J2-5 AND 11 SAME AS STEP A.
1.3.2.5			OVERCURRENT PROTECTION TEST.
	A.		16000 RPM. 167A 270.7VDC
			J2-6 - 22V J2-11 - 8.1V
			POR 270.7VDC
			LITES ARE "OFF"
	B.		LOAD INCREASED TO GREATER THAN 250A AND APPLIED
			260A FOR 7 SECONDS, GENERATOR DE-ENERGIZED
			LITES "ON"
			J2-6 AND 11 = 5.1V
	C.		OVERLOAD REMOVED. RESET, NORMAL OPERATION.

260A 182.5

FORM 1349 8/5 (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO. A.F. SIG.

NO: 22049

POWER EQUIP. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAT

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 104 ROTOR NO. STATOR NO.

DATE OF TEST 6/12/88 TEST LETTER: NO. QP387 TESTED BY R. J. SANIUK

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510121

PARA. NO.	TIME	AMB. TEMP.	
4.3.26			GENERATOR WARNING AND DISCONNECT TEST
			SIMULATED TEST. POWER RESISTOR USED IN PLACE OF DISC COIL.
	A.		1600 RPM 272 VDC
			J2-10 = 8.1 V
			J2-11 = 8.1 V
			LITES ARE "OFF"
			RES VOLTAGE "LOW" STATE
	B.		PIN 12 - J1 SHORTED TO GND (PIN 12 OF U310)
			RES VOLTAGE "Hi" STATE
			J2-10 = 11.5 V
			J2 11 = 5.1 V
			LITES ARE "ON."
	C.		REMOVE SHORTED PIN 12-J1.
			RESET SYSTEM OPERATION NORMAL.
	D		OPEN J1-PIN 10
			J2-10 = 11.5 V.
			OTHER INDICATIONS NORMAL

FORM 1349 R/S (12/62) PRECEEDING PAGE NO. FOLLOWING PAGE NO.

6.0 CONCLUSIONS

All tests performed on the generating system demonstrated that, on the whole, the system met or exceeded the requirements set down in the Navy specification. It was also demonstrated that the requirements of MIL-STD-704D and AS-1831 could also be met.

The exceptions in performance experienced are correctable by changes and additions to the generator control unit circuitry. The baseline electrical design approach of the generator is sound and would require refinements to reduce generator weight. The mechanical design approach was also demonstrated to be sound. It might be refined for weight reduction by the use of spray oil cooling in lieu of the conduction cooling used, however, some loss in efficiency could result due to the expected attendant increase in rotor oil windage losses at high rotor speeds.

Based on the results of this development and test program, which is admittedly considerably below the state-of-the-art, it is readily concluded that no insurmountable problems should be faced if baseline specifications were somewhat tightened, e.g. MIL-STD-704D and the proposed MIL-STD-704E.

7.0 References

1) NADC-60-TS-7803 Generator System, 270 volts, Direct Current, Oil Cooled, Aircraft, General Specification for, 5 January 1978.

2) MIL-STD-704D, Aircraft Electric Power Characteristics, 30 September 1980.

3) MIL-STD-704E, Aircraft Electric Power Characteristics, Preliminary.

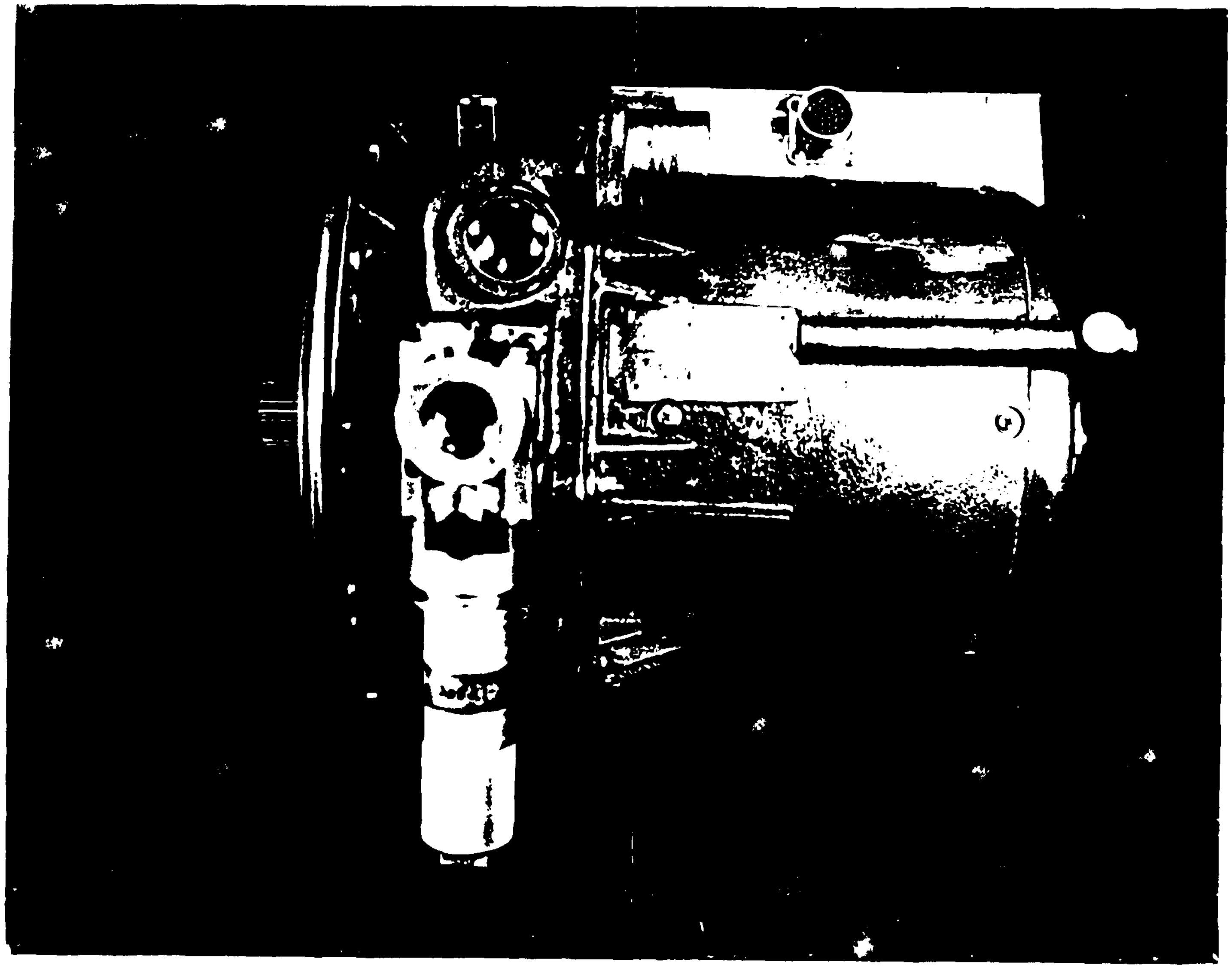
4) AS-1881 Characteristics and Utilization of Aircraft High Voltage Direct Current Electric Power, April, 1986.

APPENDIX

PHOTOGRAPHS

AND

DRAWINGS



E.W.O. 5ʼ

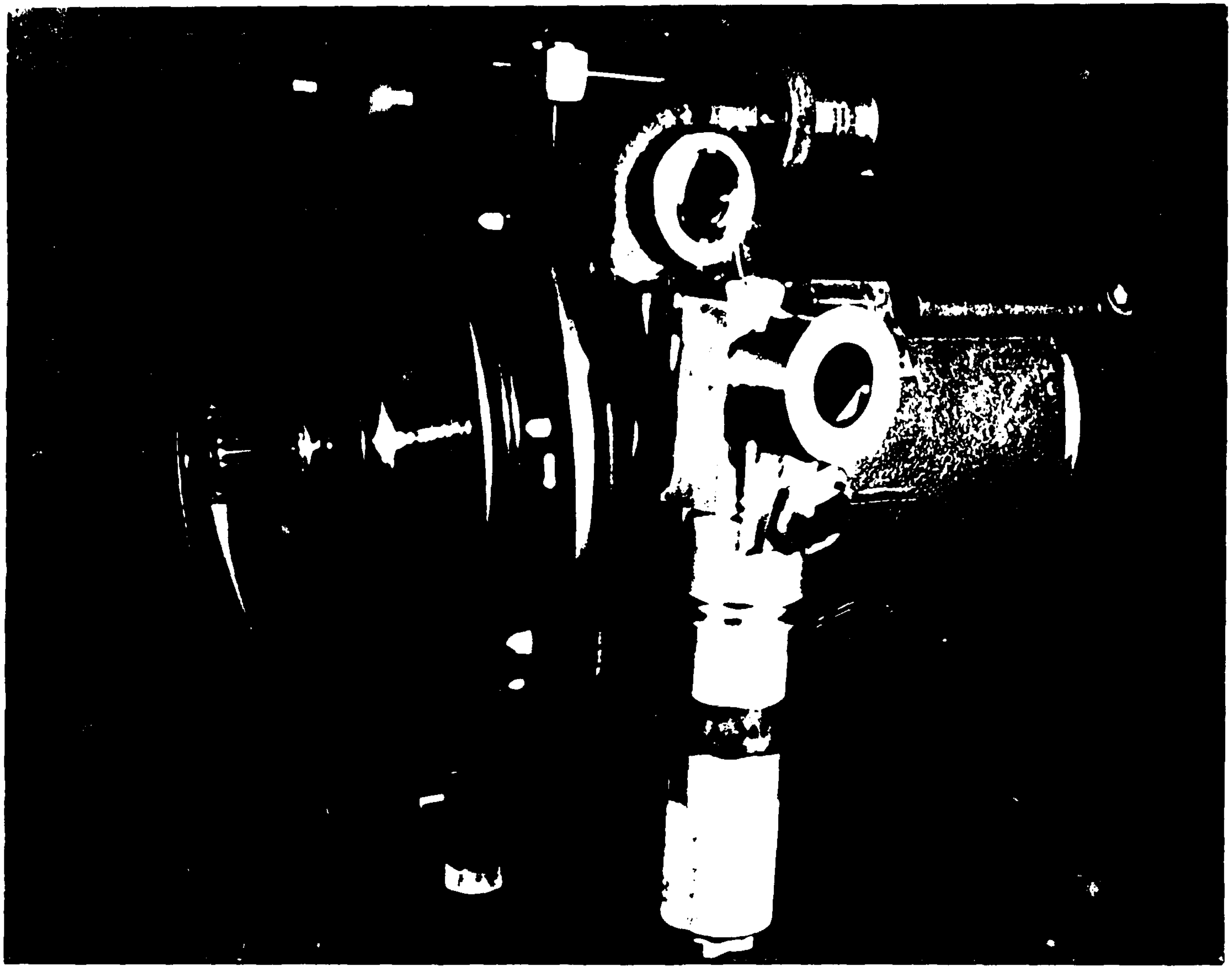
DATE OF TEST

BRUSH GRAD

TITLE: Ac

PARA. NO.	
4.3.2.8	
	C
	D
4.3.2.5	
	A
	B
	C

FORM 1



:W.O.

)ATE OF

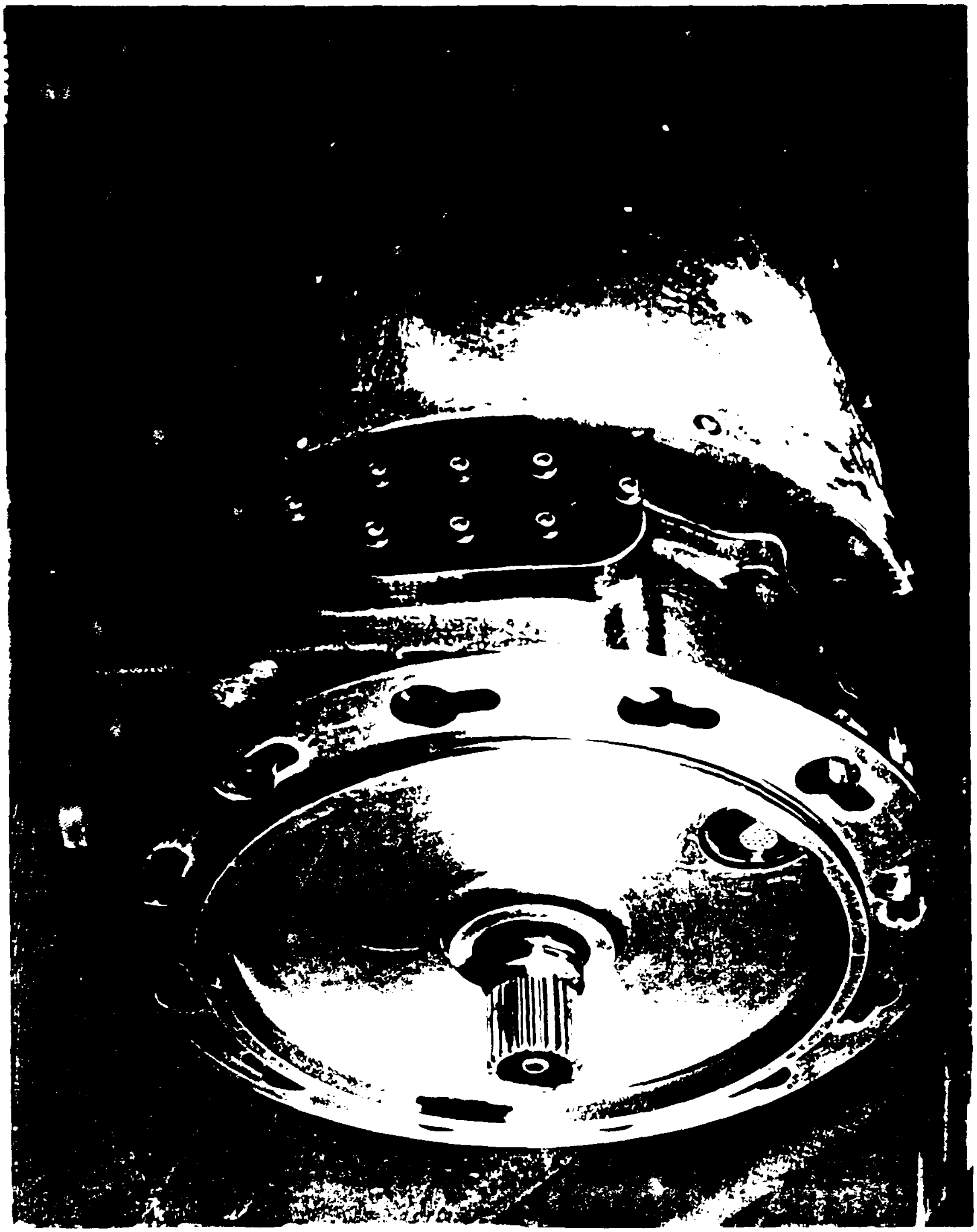
3RUSH G

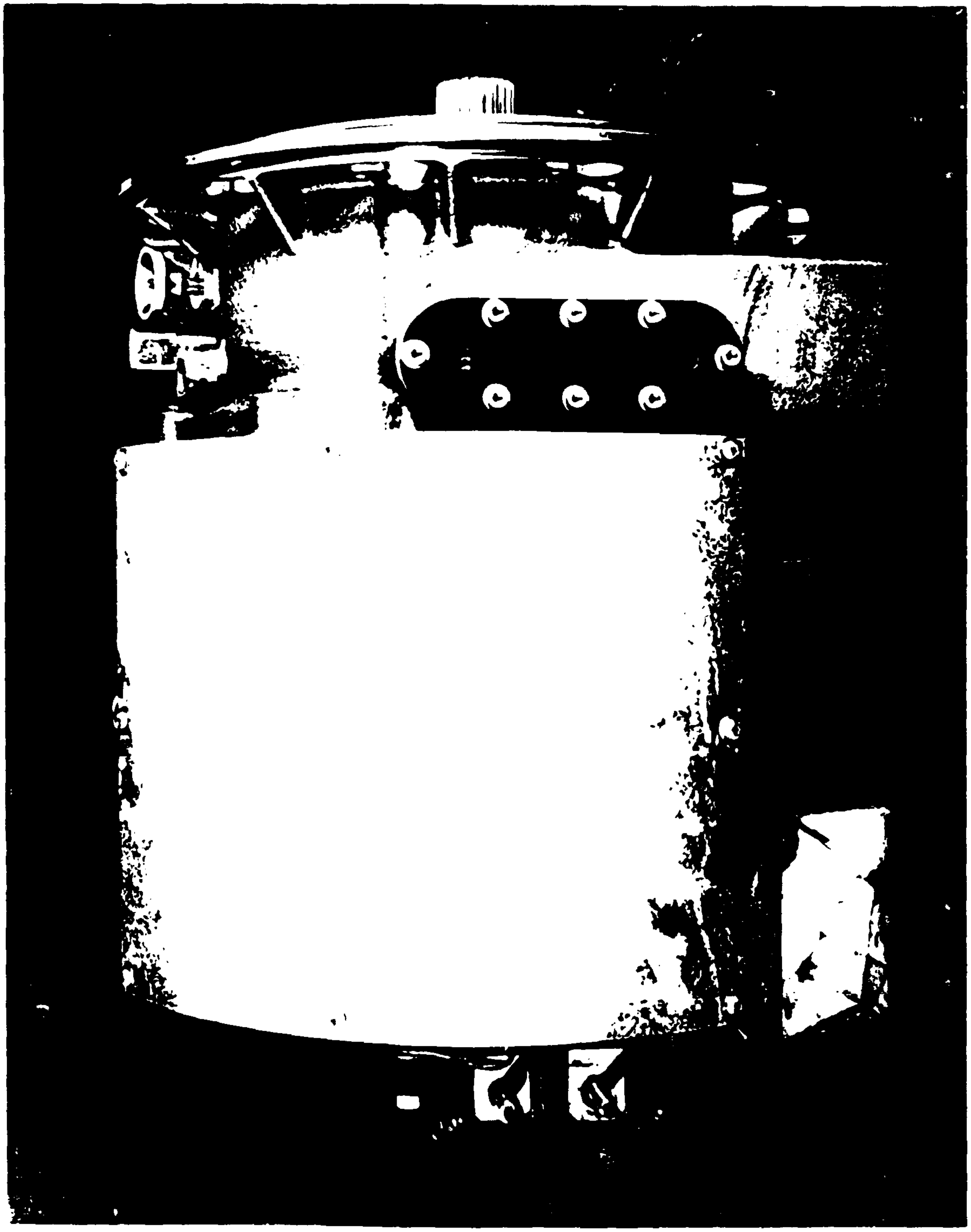
TITLE:

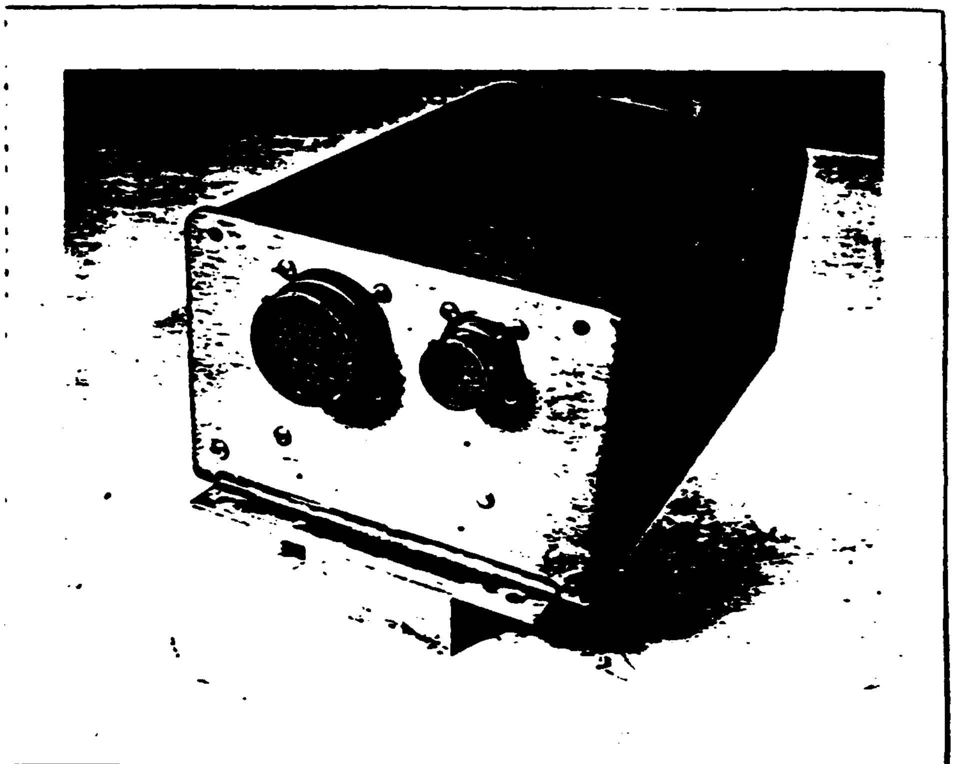
PARA. NO.

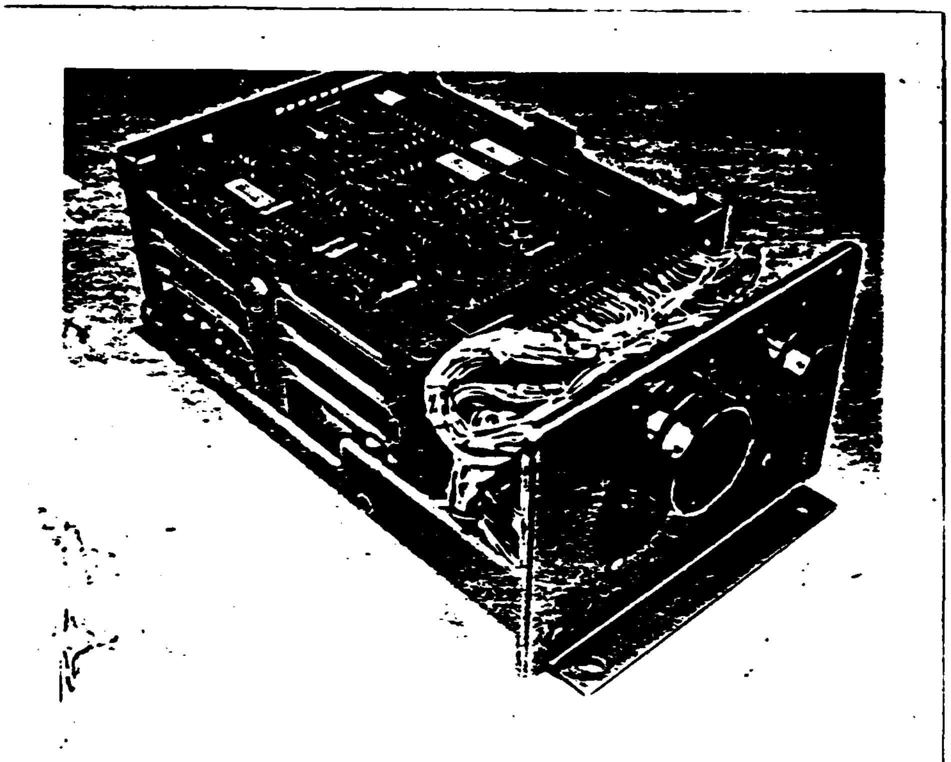
¥3 20

FOR



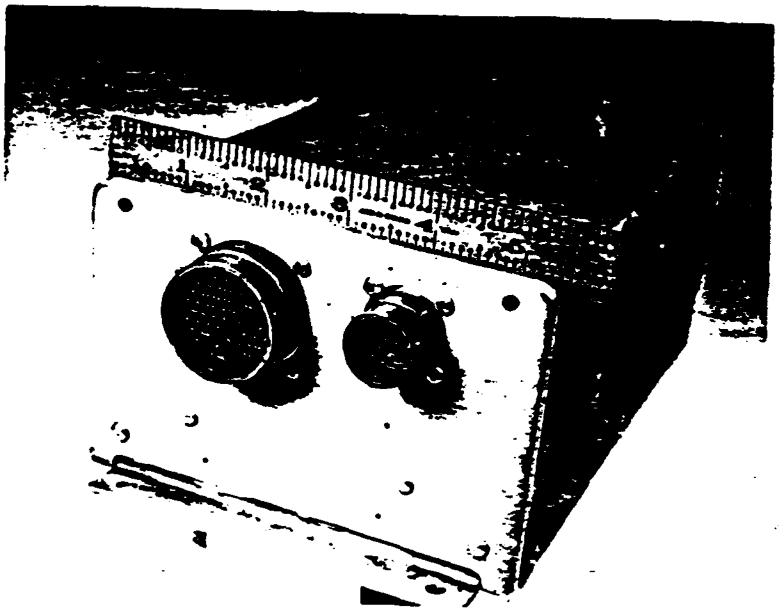


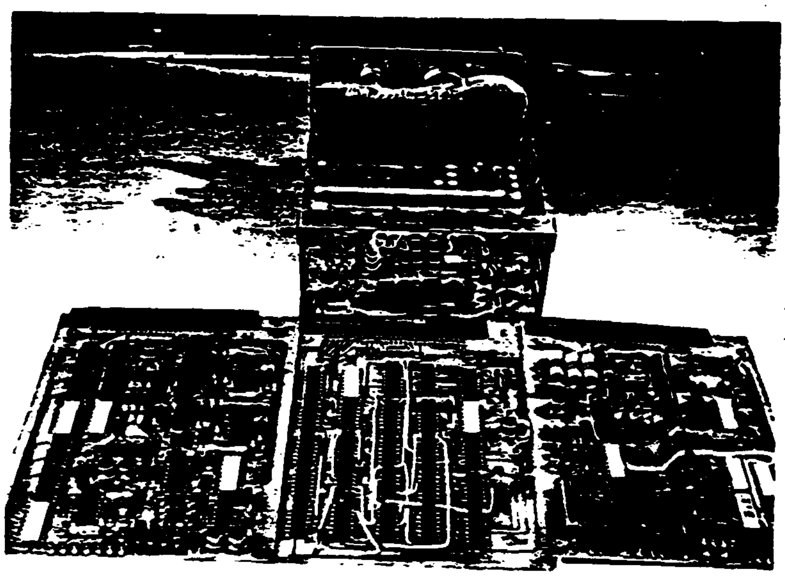




Lucas Aerospace

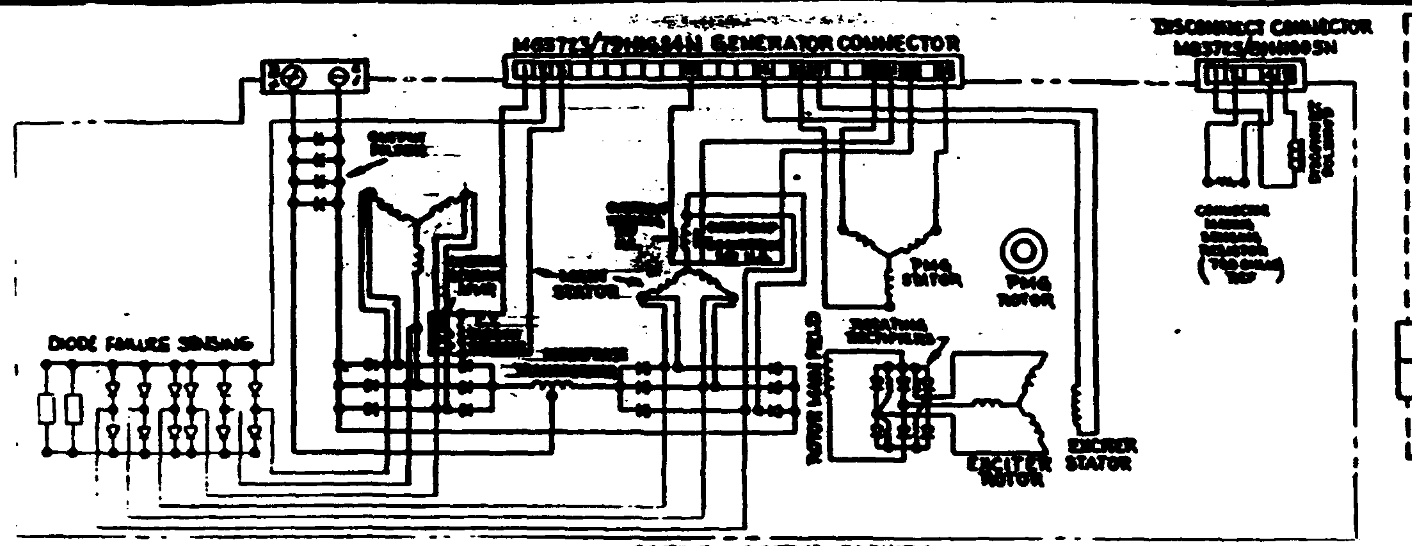
Lucas Aerospace Power Equipment Corporation



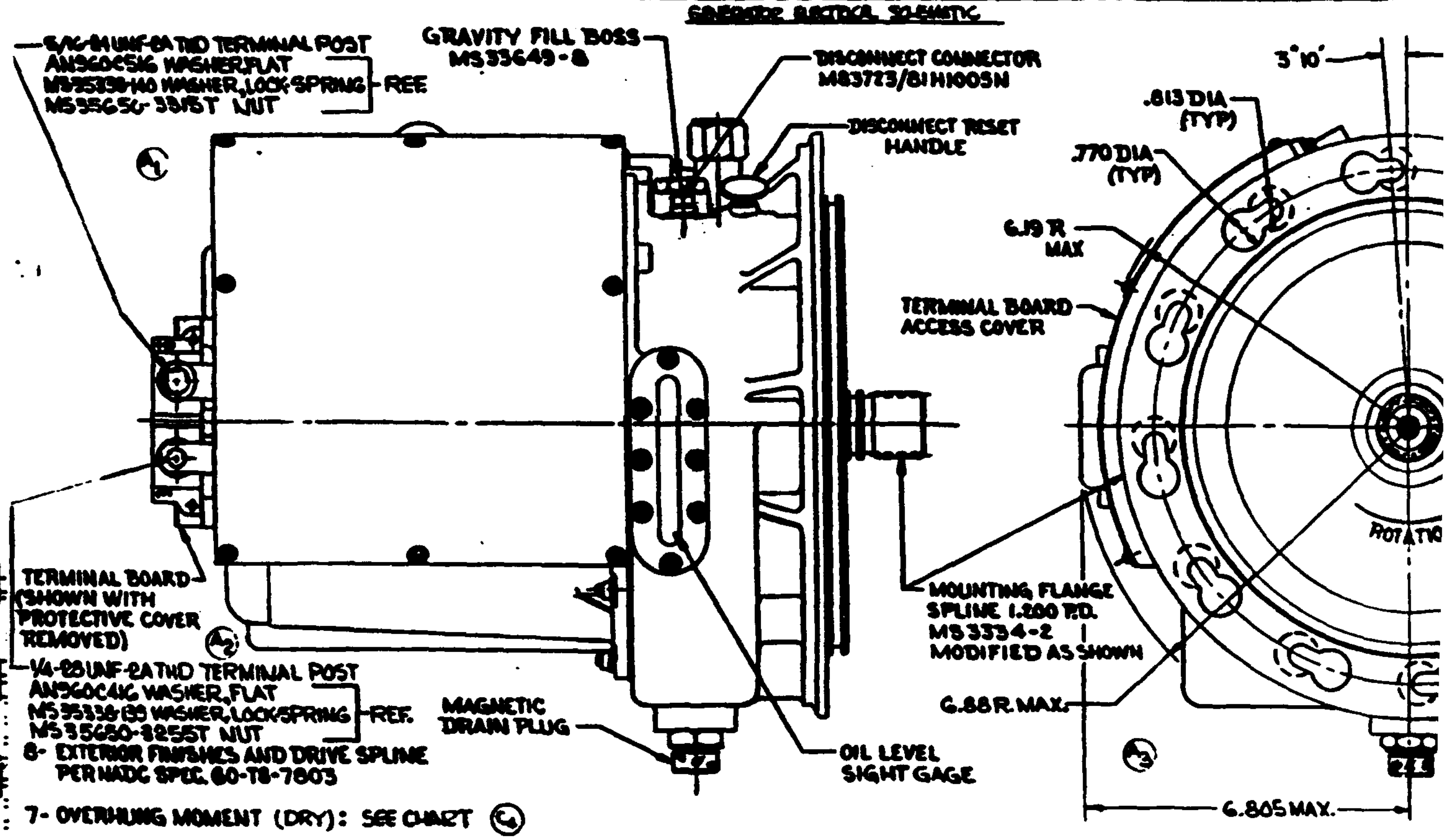


Lucas Aerospace

Lucas Aerospace Power Equipment Corporation



GENERATOR ELECTRICAL SCHEMATIC



8- EXTERIOR FINISHES AND DRIVE SPLINE PER NADC SPEC. 60-TS-7803

7- OVERHUNG MOMENT (DRY): SEE CHART (C1)

6- WEIGHT (DRY): SEE CHART (C2)

5- RATED SPEED: 9000 TO 18000 RPM
OVERSPEED: 19800 RPM
PROOF SPEED: 21600 RPM

4- RATING: 45 KW, 270 VDC, 166.7 AMPS.

3- OIL-COOLED WITH INTEGRAL OIL PUMPS PER NADC SPEC 60-TS-7803. COOLING OIL TO BE PROVIDED TO OIL INLET PORT OF GENERATOR

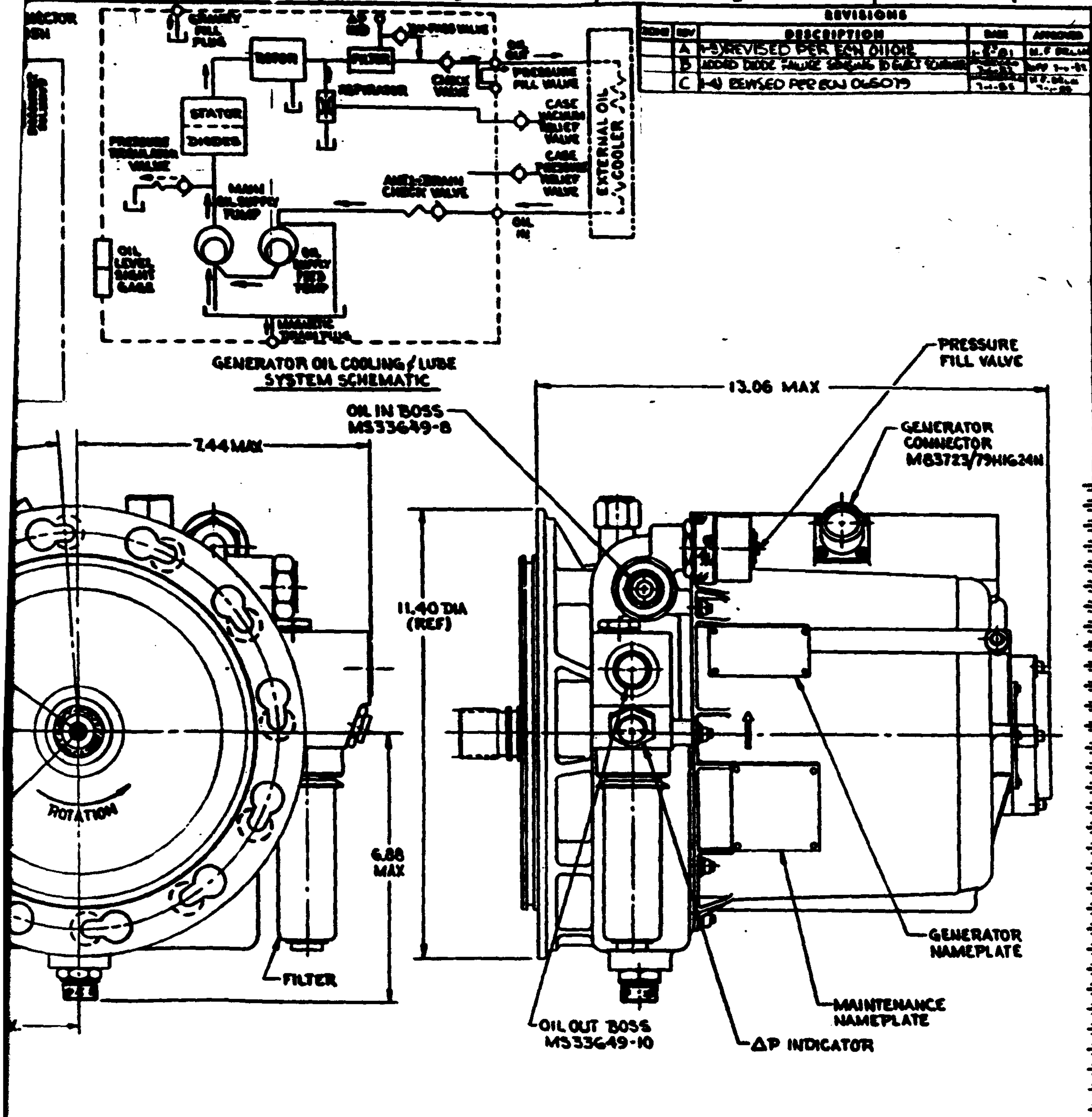
2 - [redacted]

1 - [redacted]

NOTES:

(C1)	469.4	
(C2)	451.9	
	NOTE 7 (OH.M, IN-LBS)	N (W

ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	REVISED PER ECN 011012		M.F. DELUK
	B	ADDED DIODE FAILURE SENSING		
	C	REVISED PER ECN 065079		M.F. DELUK



DIMENSIONS SHOWN ARE FOR INSTALLATION PURPOSES ONLY. DIMENSIONS WHICH ARE SPECIFIED AS MAXIMUM OR MINIMUM, OR ARE TOLERANCED, WILL BE MET. ALL OTHER DIMENSIONS ARE FOR REFERENCE ONLY.

ITEM OR FIND NO.	QTY REQ	CODE IDENT	PART NO.	DESCRIPTION

PARTS LIST

468.4	74.6	30527-001	305270001
451.9	72.0	30527-000	305270000
NOTE 7 DIM. M, IN-LBS	NOTE 6 (WT. LBS.)	MODEL NO.	OUTLINE NO.

DO NOT SCALE THIS DRAWING

DRAWN: M.F. DELUK 7-16-80

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation Aurora, Ohio 44202

GENERATOR, 270V., D.C. BRUSHLESS, SELF OIL COOLED

D | 81435 | 305270000/0001

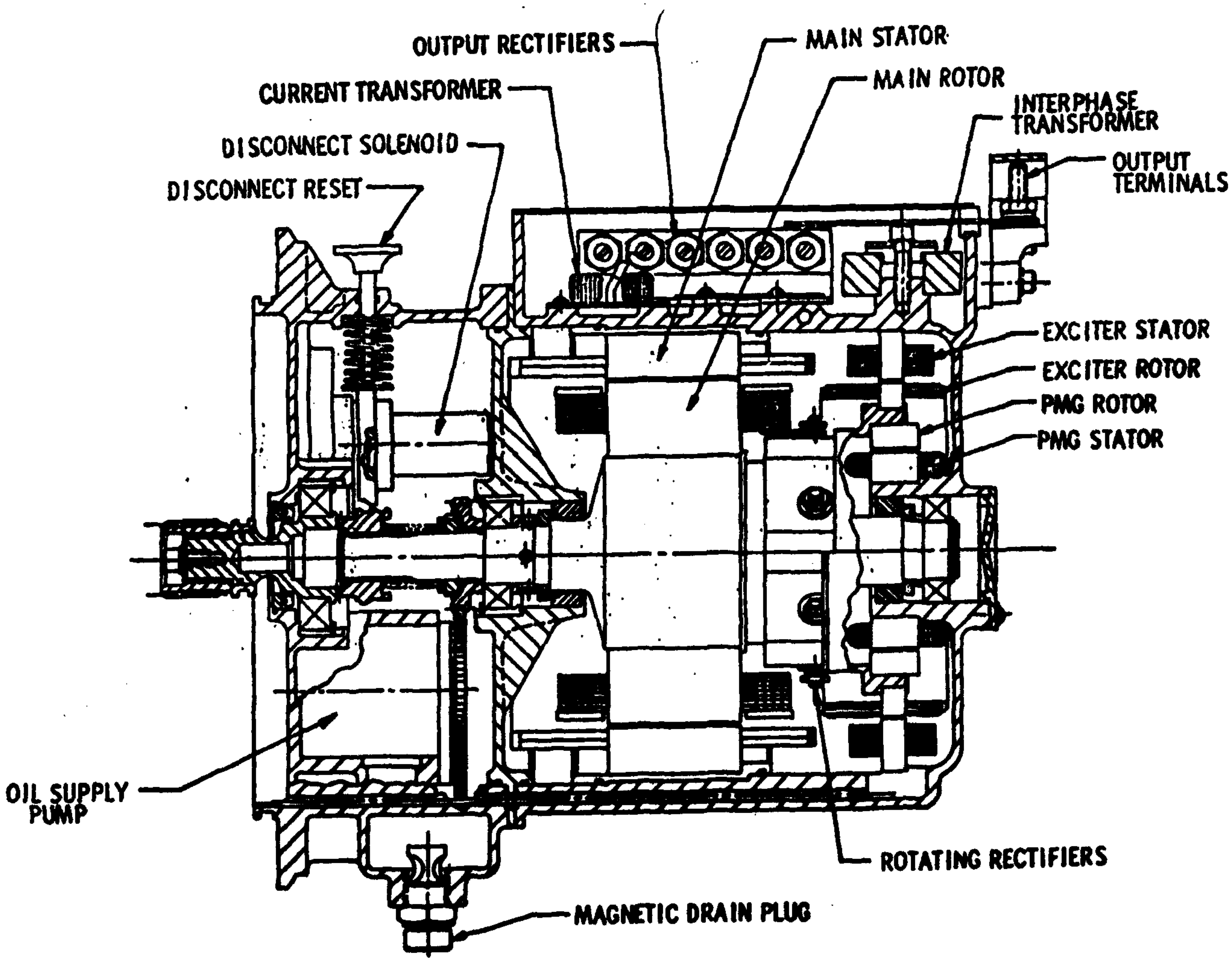
SHEET 1 OF 1

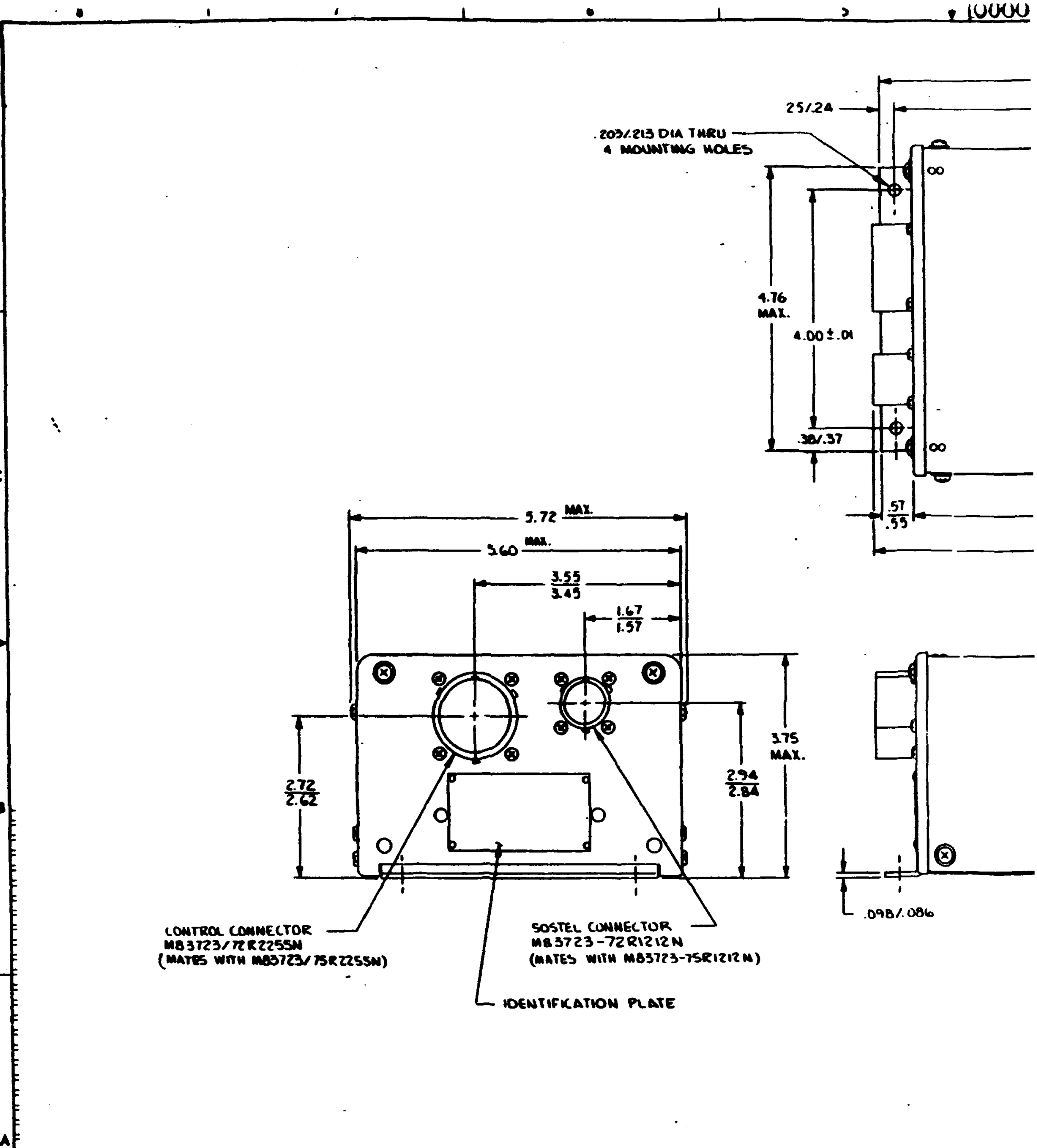
(7)

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

GENERATOR/ADAPTER CUTAWAY





3 - WEIGHT: 6.0 LBS. MAX.

2 - ~~[illegible]~~

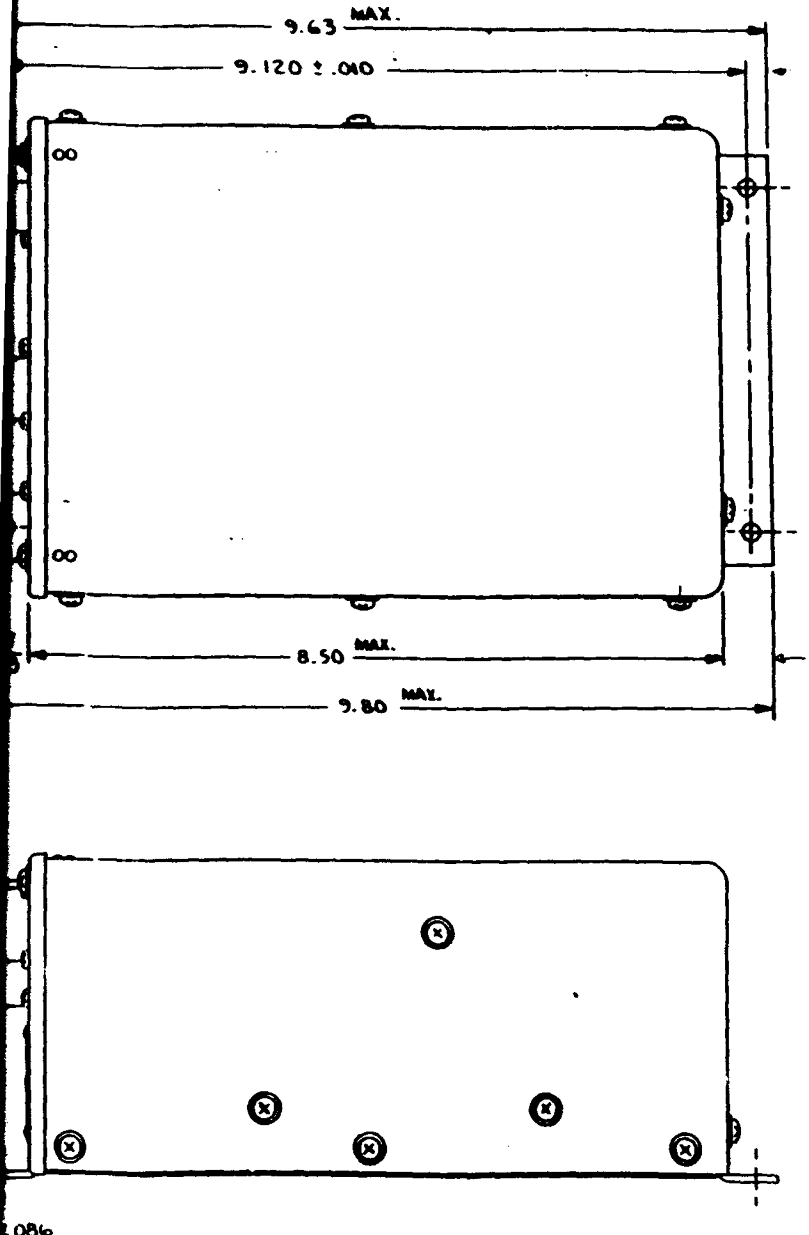
1 - ~~[illegible]~~

NOTES:

D

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	LINED OUT NOTES 1 & 2 REVISED NOTE 3 WAS 5 LBS.	8-26-81	



ITEM OR FIND NO.	QTY REQ	CODE IDENT	PART NO.	DESCRIPTION

PARTS LIST

NEXT ASSY	USED ON
FIRST APPLICATION	

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCE ON: DECIMALS .XX ± .03 .XXX ± .005 ANGLES ± 0° 30'

DO NOT SCALE THIS DRAWING

MATERIAL

DRAWN BY S. S. ZELENAK 4-16-80
CHECKED BY DATE
MATL APVD DATE
MFG ENGR DATE
PROJECT ENGR 4-26-80
CONTRACT NO.

Lucas Aerospace

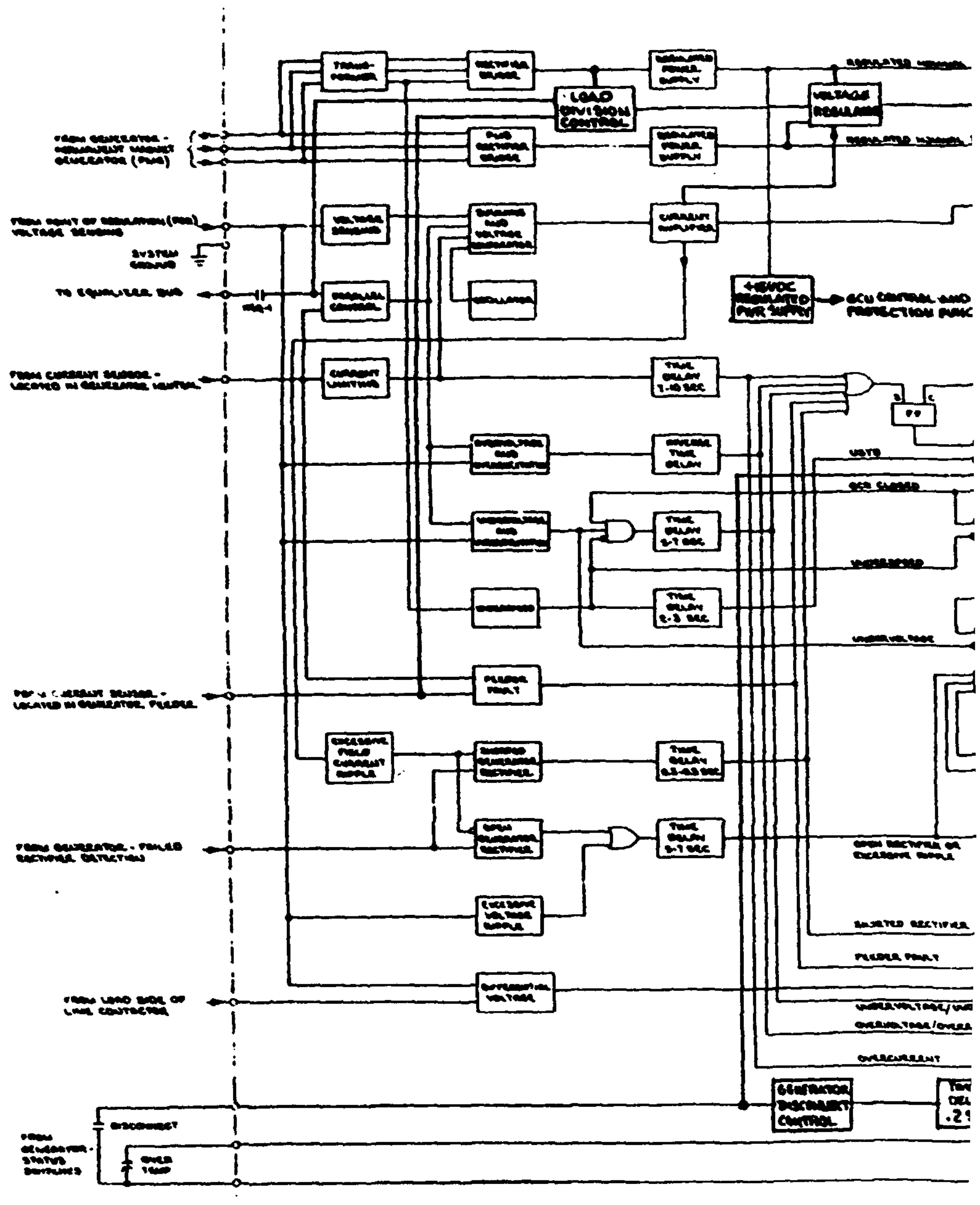
Lucas Aerospace Power Equipment Corporation Aurora, Ohio 44202

GENERATOR CONTROL UNIT, FOR BRUSHLESS 270 VDC GENERATOR

SIZE D FSCM NO. 31435 DWG NO. 515270000

SCALE 1/1 SHEET 1 OF 1

(2)

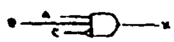


LEGEND

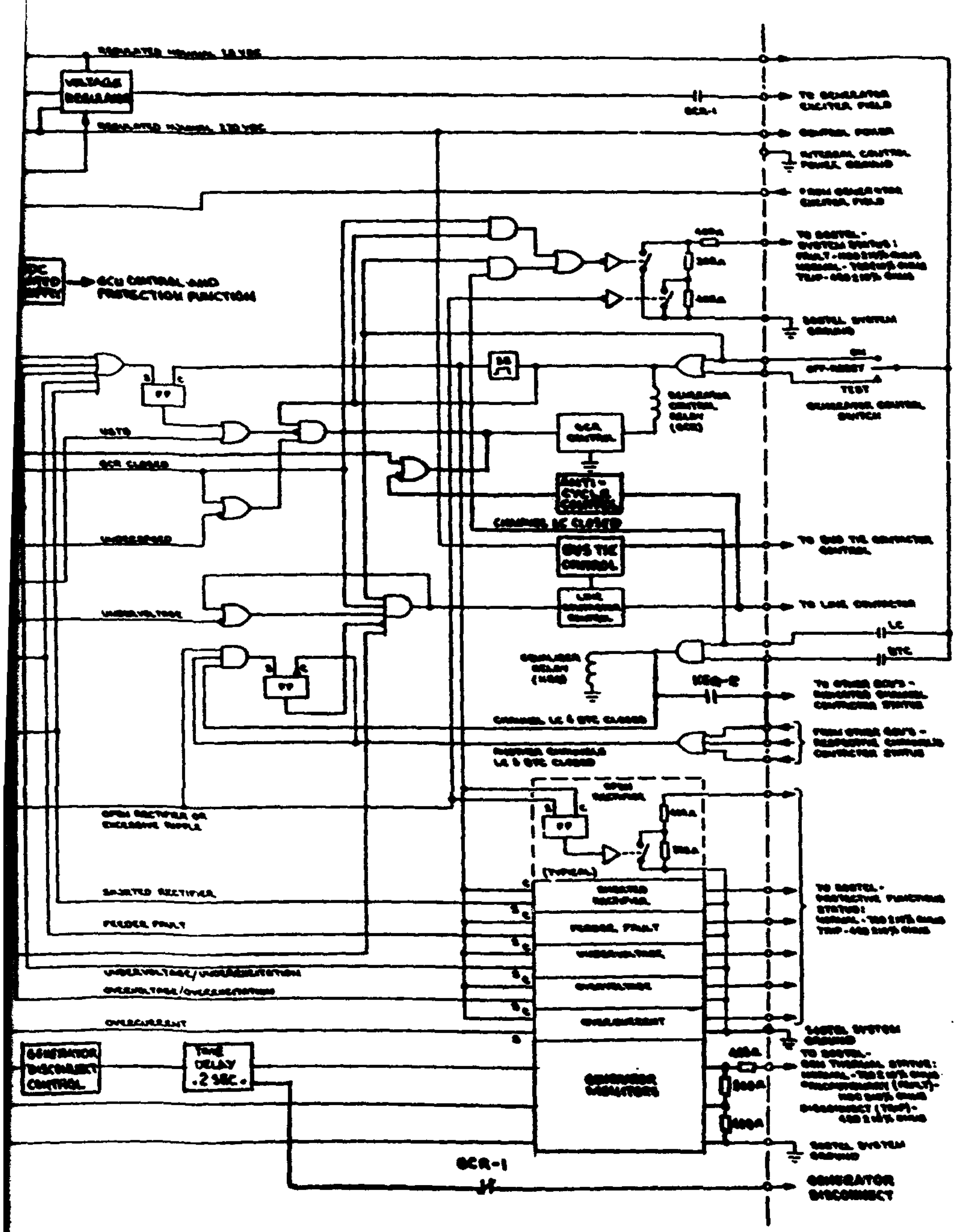
BTC	BUS TIE CONTACTOR
FF	FLIP-FLOP
GCR	GENERATOR CONTRO
GCU	GENERATOR CONTRO
KEQ	EQUALIZER RELAY
LC	LINE CONTACTOR
PMG	PERMANENT MAGNET
POR	POINT OF REGULATI
SS	SINGLE-SHOT
TEMP	TEMPERATURE
USTD	UNDERSPEED TIME

NOTES:

1. [illegible]
2. [illegible]
3. LOGIC SYMBOLS USED ARE IN ACCORDANCE WITH MIL-STD-806
4. THE FLIP-FLOP (FF) IS A BISTABLE FUNCTION. A PULSE SIGNAL RECEIVED AT THE S (SET) INPUT AND REMOVED WILL CAUSE THE FF TO PROVIDE A CONTINUOUS OUTPUT. THE FF OUTPUT IS REMOVED BY APPLYING A PULSE SIGNAL AT THE C (CLEAR) INPUT.
5. LOGIC SYMBOLS: A SMALL CIRCLE AT THE INPUT TO ANY LOGIC ELEMENT INDICATES THAT THE PRESENCE OF THIS SIGNAL INHIBITS THE FUNCTION. AN INPUT TO ANY LOGIC ELEMENT WITH NO SMALL CIRCLE INDICATES THAT THIS SIGNAL ACTIVATES THE FUNCTION. EXAMPLE:



(1)



LEGEND

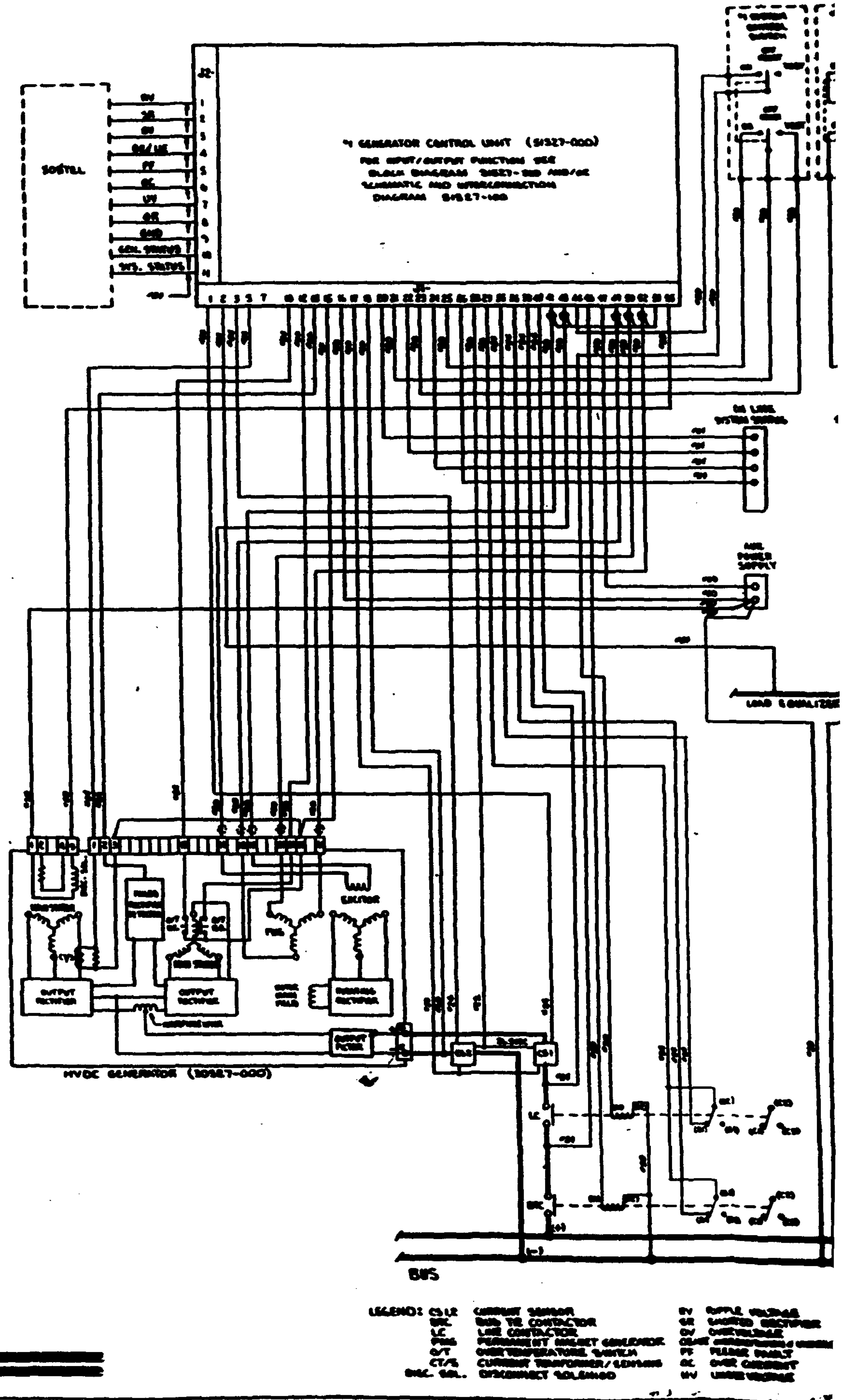
BUS TIE CONTACTOR
FLIP-FLOP
GENERATOR CONTROL RELAY
GENERATOR CONTROL UNIT
EQUALIZER RELAY
LINE CONTACTOR
PERMANENT MAGNET GENERATOR
POINT OF REGULATION
SINGLE-SHOT
TEMPERATURE
UNDERSPEED TIME DELAY

PARTS LIST

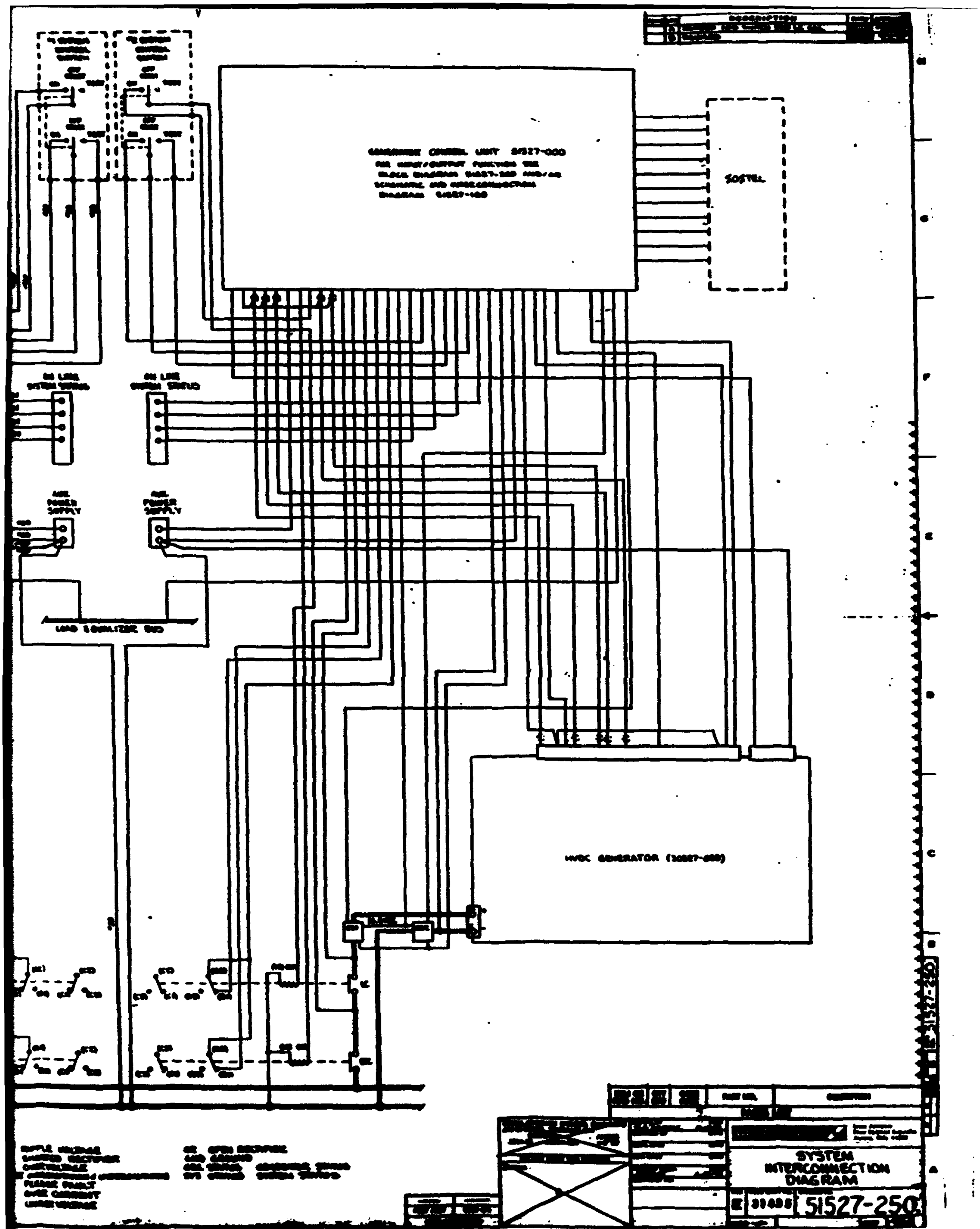
CONTROL DIAGRAM,
GENERATOR CONTROL UNIT,
HVDC SYSTEM

31435 51527-200

(2)

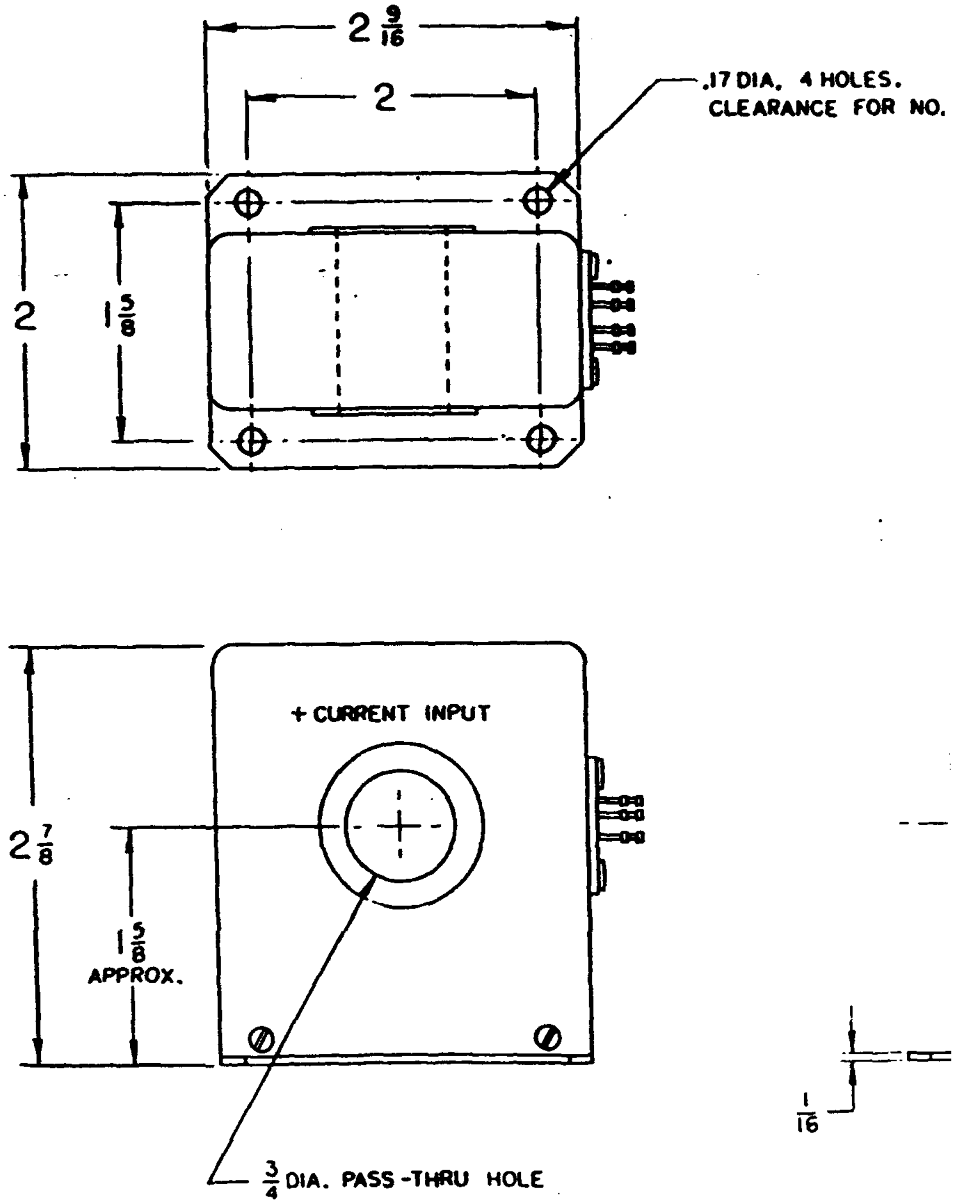

GENERATOR CONTROL UNIT
OUTPUT RECTIFIER
OUTPUT RECTIFIER
OUTPUT FILTER
EXCITOR
HVDC GENERATOR
LOAD EQUALIZER
BUS
LEGEND: CS1,2 CURRENT SENSOR
BTC BUS TIE CONTACTOR
LC LINE CONTACTOR
PMG PERMANENT MAGNET GENERATOR
O/T OVERTEMPERATURE SWITCH
DISC. SOL. DISCONNECT SOLENOID
OV OVERVOLTAGE
FF FEEDER FAULT
OC OVER CURRENT
UV UNDERVOLTAGE

[redacted]



SOSTEL
ON LINE SYSTEM STATUS
AUX. POWER SUPPLY
HVDC GENERATOR
SYSTEM INTERCONNECTION DIAGRAM
E
51527-250

(2)



—	—
NEXT ASSY	USED ON
FIRST APPLICATION	

1 - WEIGHT: 1.7 lbs

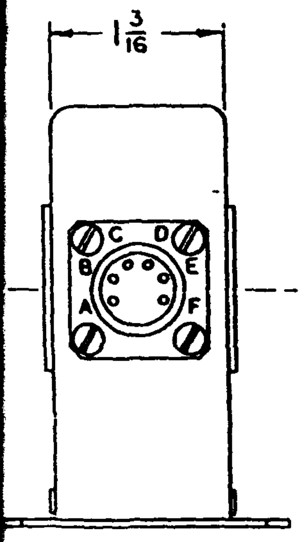
NOTE(S):

(1)

DWG NO. 50527000

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	ADDED NOTE 1	ZELENAK 8-27-91	8/27/91

NO. 8 SCREW.



DWG NO. 505270000

REV A

FILES

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES [redacted]	DRAWN BY S.J. ZELENAK DATE 8FEB88	Lucas Aerospace — Lucas Aerospace Power Equipment Corporation Aurora, Ohio 44202
DO NOT SCALE THIS DRAWING	CHECKED BY DATE	OUTLINE DRAWING, D.C. CURRENT SENSOR
MATERIAL: AMERICAN AEROSPACE CONTROLS, INC SERIES 934	MATL APVD DATE	
	MFG ENGR DATE	
	PROJECT ENGR (MECH/ELECT) DATE 2-8-88	SIZE B — FSCM NO. 31435 — DWG. NO. 505270000
	CONTRACT NO.	SCALE NONE — SHEET 1 OF 1

AF___N___A___CUST______

PTI ASSIGNED

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